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Preface

Striped bass (*Morone saxatilis*) have historically supported one of the most important recreational and commercial fisheries along the Atlantic coast. In colonial times striped bass were abundant in most coastal rivers from New Brunswick to Georgia but overfishing, pollution and reduction of spawning habitat have resulted in periodic declines in stocks and an overall reduction of biomass (Merriman 1941, Pearson 1937). Striped bass populations at the northern and southern extremes of the Atlantic coast are apparently non-migratory (Raney 1957). Presently, important sources of striped bass are limited to the Roanoke, Delaware and Hudson rivers and the major tributaries of Chesapeake Bay (Lewis 1957), with the Chesapeake Bay and Hudson River being the primary sources of the coastal migratory population (Dorazio *et al*. 1994).

Examination of meristic characteristics indicate that the coastal migratory population consists of distinct sub-populations from the Hudson River, James River, Rappahannock - York rivers, and upper Chesapeake Bay (Raney 1957). The Roanoke River striped bass may represent another distinct sub-population (Raney 1957). The relative contribution of each area to the coastal population varies. Berggren and Lieberman (1978) concluded from a morphological study that Chesapeake Bay striped bass were the major contributor (90.8%) to the Atlantic coast fisheries, and the Hudson River and Roanoke River stocks were minor contributors. However, they estimated that the exceptionally strong 1970 year class constituted 40% of their total sample. Van Winkle *et al.* (1988) estimated that the Hudson River stock constituted 40% - 50% of the striped bass caught in the Atlantic coastal fishery in 1965. Regardless of the exact proportion, management of striped bass is truly a multi-jurisdictional concern as spawning success in one area certainly influences fishing success in many areas.

Concern about the decline in striped bass landings along the Atlantic coast since the mid-1970s prompted the development of an interstate fisheries management plan (FMP) under the auspices of the Atlantic States Marine Fisheries Management Program (ASMFC 1981). Federal legislation was enacted in 1984 (Public Law 98-613, the Atlantic Striped Bass Conservation Act) which enables Federal imposition of a moratorium for an indefinite period in those states that fail to comply with the coastwide plan. To be in compliance with the plan, coastal states have imposed restrictions on their commercial and recreational striped bass fisheries, ranging from combinations of catch quotas, size limits and time-limited to year-round moratoria. Due to an improvement in spawning success, as judged by increases in annual values of the Maryland juvenile index, a limited fishery was established in fall, 1990. This transitional fishery existed until 1995 when spawning stock biomass reached sufficiently healthy levels (Field 1997). ASMFC subsequently declared Chesapeake Bay stocks to have reached benchmark levels and adopted Amendment 5 to the original FMP that allowed expanded state fisheries. A history of striped bass management and a compilation of the long time-series of data on Atlantic striped bass collected by state and federal agencies is provided by Shepherd and Lazar (1998).

To document continued compliance with Federal law, the Virginia Institute of Marine Science (VIMS) Anadromous Program (AP) has monitored the size and age composition, sex ratio and maturity schedules of the spawning striped bass stock in the Rappahannock River since December 1981 utilizing commercial pound nets and, since 1991, variable-mesh experimental anchored gill nets. Spawning stock assessment was expanded to include the James River in 1994 utilizing extant commercial fyke nets and variable-mesh experimental gill nets. The use of fyke nets was discontinued after 1997. Tagging programs have been conducted in the James and Rappahannock rivers since 1987 in conjunction with the monitoring studies. These studies were established to document the migration and relative contribution of these Chesapeake Bay stocks to the coastal population and to provide a mean to estimate inter-year survival rates (S). The tagging studies were expanded to the York River and western Chesapeake Bay to provide a direct estimation of the resultant fishing mortality (F) with the re-establishment of fall recreational fisheries in 1993 .

Because of low stock levels of striped bass in the recent past, and the variable nature of their population dynamics, Chesapeake Bay stocks may or may not be contributing their full potential to the coastal population which supports the fisheries north of Chesapeake Bay. Therefore, the information contained in this report is important to the development and implementation of a coordinated management plan for striped bass in Virginia, and along the eastern seaboard.

Executive Summary

Rappahannock River

1. In 1998, 817 striped bass were sampled from three commercial pound nets in the Rappahannock River. The samples were predominantly male (85.5%) and young (71.3% ages three to four). Females dominated the age-nine and older age classes (98.8%).

2. In 1998, net-specific differences in catch rates were observed in pound nets. Catches in the upriver net were usually (but not always) higher than catches in the down-river net. The intermediate pound net had catches similar to the upriver net. The age composition of striped bass was similar among the three pound nets.

3. In 1998, 603 striped bass were sampled in two variable-mesh anchor gill nets in the Rappahannock River. The samples were predominantly male (95.2%) and young (78.6% ages 3-4). Old females (pre-1985 year classes) were absent in gill net catches, although present in pound net samples.

4. The total catch from gill net No. 2 (n= 432) exceeded the total catch from gill net No.1 (n= 171), due to large catches of male striped bass in net No.1 on 30 March and 13 April. The age composition of the striped bass captured were similar in both nets except for a larger catch of females age nine and age ten in net No. 1.

5. From 1993-1998, 3,785 striped bass were sampled from among the three pound nets, and 3,782 striped bass were sampled from the two variable-mesh gill nets in the Rappahannock River. During the period, start dates varied from 9 March (1998) to 7 April (1994); end dates varied from 21 April (1997) to 3 May (1993); two pound nets were sampled in 1993-1996 and three pound nets in 1997-1998; fishing effort of the pound nets varied from 48-168 hrs, but was usually 72 or 96 hours while the gill nets were consistently fished for 24 hrs. A sampling rotation for the pound nets, envisioned to be equal among the nets throughout each season, was often interrupted due to weather or market constraints, and resulted in disproportionate sampling of the down-river net in 1993 and 1996.

6. To facilitate comparisons between years, we constrained the analysis to a temporal window of 30 March - 3 May in each year. This window included most of the annual influx of female striped bass into the spawning grounds, and eliminated consideration of the third pound net in 1997. However, by restricting the sampling window, fewer fish were considered in the analysis (38% fewer males and 16% fewer females) and fewer days were used in the computation of annual mean catch rates. Thus, using the restricted sampling window elevated catch rates and mean age of both sexes compared to using all available data from the entire season nets.

7. For the 1993-1998 period, annual catch rates at the upriver pound net always exceeded those for the down-river net. The intermediate pound net, introduced in 1997, had catches similar to the upriver net. The mean ages of both male and female striped bass was highest in catches from the down-river net.

8. During 1993-1998, catch rates were generally higher in gill net No. 1 (four out of six years) than in gill net No. 2, especially for male striped bass. However, age composition and mean ages of both sexes were nearly identical.

9. The susceptibility of striped bass to the gill nets varied with mesh size. Male striped bass, especially those six years of age and younger, were vulnerable to the 3.0- to 5.25-inch meshes (92.4% of total males by number and 82.7% by weight). Catches of female striped bass were greatest from the 6.0- to 8.0-inch mesh panels (62.0% by number and 72.5% by weight).

10. For the 1993-1998 period, there was a temporal trend towards larger numbers of younger males and older females. During the period, the proportion of males older than five and the proportion of females younger than eight years declined.

11. The mean age of female striped bass captured from the pound nets was older in every year, and significantly different in every year except 1995, than those captured from the gill nets. In contrast, the mean ages of male striped bass were similar between the gears, differing significantly only in 1995.

12. Total catch rates (numbers of fish per day) from the pound nets were highest in 1993 and 1997, but relatively stable in the other years. Total catch rates from the gill nets were very high in 1997, low in 1995, and stable in the other years.

13. Year class-specific estimates of annual survival (S) were higher from the pound net data than from the gill net data. Survival estimates of the 1987-1991 year classes varied from 0.56-0.75 based on pound net data but only 0.33-0.48 using gill net data. Survival estimates of female striped bass were approximately twice those of male striped bass.

14. Spawning stock biomass indexes (SSBI) showed a decline from 1993-1996, a sharp peak in 1997, and an intermediate value in 1998. The female-specific SSBI declined from 1993-1996 in both gears, but rebounded in 1997 and 1998 in the pound net data. The male SSBI was highest in 1997 and lowest in 1995 from both gears but otherwise varied with no temporal trend.

James River

15. In 1998, 236 striped bass were sampled from two variable-mesh gill nets in the James River. The samples were predominantly male (69.5% of the total number) and young (55.1% were ages four to five). Females dominated the catch over age eight, making up 92.6% of the total.

16. The total catch from gill net No. 1 (n= 161) exceeded the total catch from gill net No. 2 (n= 75), due to large catches of mostly male striped bass in net No. 1 on 2 April and on 9 April. The age structure of the striped bass sampled from the two nets differed. All of the males over age 8 were captured in net No. 2.

17. From 1994-1998, 1,314 striped bass were sampled from the two variable-mesh gill nets in the James River (only one net was sampled in 1994). From 1994-1997, 1,917 striped bass were sampled from two commercial fyke nets (only one net was sampled in 1994). During the period, start dates varied between 27 Feb. and 21 March; end dates varied between 27 Apr. and 9 May; fishing effort of the fyke nets varied between 24 and 196 hours. A second fyke net and gill net was added in 1995. Sampling of commercial fyke nets was discontinued after 1997.

18. As with the Rappahannock River data, we constrained the analysis of James River data to a temporal window of 30 March - 3 May in each year. By restricting the sampling window, fewer fish were considered in the analysis (18% fewer males from fyke nets, 23% fewer from gill nets; and 14% fewer females from both fyke nets and gill nets) and fewer days were used in the computation of annual mean catch rates. Using the restricted sampling window in the James River data elevated catch rates compared to using all available data from the entire season, but resulted in no differences in the mean ages of either sex in either gear.

19. From 1994-1997, catches of male striped bass (especially ages two and three) were much higher in samples from the near-channel fyke net while more female striped bass were captured in the near-shore fyke net. Tests of the age-frequency distributions rejected the hypothesis that the male striped bass captured in the two fyke nets came from populations with the same age structure. These differences were not observed for females in fyke nets.

20. From 1995-1998, more striped bass were captured in gill net No. 1 (n= 537) than in gill net No. 2 (n= 424). The overall mean ages of male striped bass sampled from the two nets were identical (4.6 years). The overall mean age of the female striped bass sampled from net No. 2 (7.5 years) exceeded that of net No. 1 (6.8 years), but the difference in mean ages from 1996-1998 were small.

21. The susceptibility of striped bass to the gill nets varied with mesh size. The catches of the 3.75- to 5.25-inch mesh panels were predominantly male (80.9% of the total). Female striped bass were most frequently captured in the 6.0- to 10.0-inch mesh panels, and comprised 88.0% of the total catch from the 8.0- to 10.0-inch mesh panels.

22. From 1995-1998, the mean age of males increased from 4.0 to 4.5 years, and the mean age of females increased from 6.5 to 7.5 years (7.9 years in 1997).

23. Catch rates (number of fish/day) were higher in 1994-1995 than in 1996-1998. All years classes since 1988 reached their maximum abundance in the gill nets at age four or five. The relative abundances of the age classes indicated that the 1989 and 1990 year classes were strong contributors to the spawning stocks, and the 1992 year class was a weak contributor from 1994-1998. The relative abundance of ten and eleven year old striped bass indicated that the 1984 and 1987 year classes were strong contributors to spawning stocks in the early 1990's.

24. Judging by catch rates of males, peak abundance in the gill nets occurred at ages 3-5. No males older than six years were captured in 1994. Overall, the abundance of the 1989-1991 and the 1994 year classes was above average, and the abundance of the 1992 and 1993 year classes was below average. Cumulative catch rates of male striped bass were highest in 1994 and 1995, declined greatly in 1996 and 1997, then rebounded somewhat in 1998.

25. Sex-specific catch curves illustrated the rapid decline in abundance of male striped bass after age five. Female striped bass also declined rapidly from ages five to seven but showed a secondary peak of abundance after age nine.

26. Survival estimates based on annual age structures varied from 0.50-0.57 for the 1989-1991 year classes and 0.63-0.68 for the 1987 and 1988 year classes. Survival estimates for male striped bass were lower than for female striped bass in each year class.

27. Spawning stock biomass indexes for the James River were highest in 1995, lowest in 1996 and remained below average in 1997-1998.

Assessment of the spawning stocks of striped bass in the Rappahannock and James rivers, Virginia, 1993-1998.

Introduction

Every year, striped bass migrate along the US east coast from offshore and coastal waters and enter brackish or fresh water to spawn. Historically, the principal spawning areas in the northeastern US have been the Hudson, Delaware and Chesapeake estuarine systems (Hardy 1998). The importance of the Chesapeake Bay spawning grounds to these stocks has long been recognized (Merriman 1941, Raney 1952). In the Virginia tributaries of Chesapeake Bay, peak spawning activity is usually observed in April and is associated with rapidly rising water temperatures in the range of 13-19^0 C (Grant and Olney 1991). Spawning is often completed by mid-May, but may continue until June (Chapoton and Sykes 1961). Spawning grounds have been associated with rock-strewn coastal rivers characterized by rapids and strong currents on the Roanoke and the Susquehanna rivers (Pearson 1938). In Virginia, spawning occurs over the first 40 km of tidal freshwater portions of the James, Rappahannock, Pamunkey and Mattaponi rivers (Grant and Olney 1991; Olney et al. 1991; McGovern and Olney 1996).

The Atlantic States Marine Fisheries Commission (ASMFC) declared that the Chesapeake Bay spawning stocks were fully recovered in 1995 after a period of very low stock abundance in the 1980's. This statement of recovered status was based on estimated levels of spawning stock biomass that were found in 1995 to be equal or greater than the average levels of the 1960-72 period (Rugulo et al. 1994). Thus, continued assessment of spawning stock abundance is an important component of ASMFC mandated monitoring programs. To this end, the Anadromous Fishes Program at the Virginia Institute of Marine Science (VIMS) began development of spawning indexes that depict annual changes in catch rates of striped bass on the spawning grounds of the James and the Rappahannock rivers. These rivers represent the major contributors to the Chesapeake bay stocks that originate from Virginia waters.

Materials and Methods

Samples of striped bass for biological characterization of the spring spawning stocks were obtained from the Rappahannock and James rivers in 1993-1998. Sampling generally commenced in early to mid-March and continued through late April or early May, when the number of gravid and still-maturing female striped bass diminished (Table 1). Samples (the entire catch of striped bass from each gear) were taken twice-weekly (usually Monday and Thursday) from a set of two commercial pound nets (river miles 44 and 47) in 1993-1996 or from a set of three pound nets (river miles 44, 46 and 47) in 1997-1998 on the Rappahannock River. During each week, the choice of pound nets that were sampled was often dictated by weather and market conditions. Thus, in certain years or certain weeks, there was uneven sampling among the pound nets. In addition to the pound nets (Figures 1-2), samples were

obtained from variable-mesh experimental anchored gill nets (two each at river mile 48 on the Rappahannock River and river mile 55 on the James River), and two fyke nets (river mile 55, 1994-1997). Pound nets and fyke nets are fixed commercial gears that have been historically predominant gear types used in both rivers. Neither are presumed to be size-selective in their catches of striped bass. The retirement or departure of fyke-net fishermen on the James River prevented the use of this gear for stock assessment in 1998.

The variable-mesh gill nets deployed on both rivers were constructed of ten panels, each measuring 30 feet (9.14 m) in length, and 10 feet (3.05 m) in depth. The ten stretched-mesh sizes (in inches) were 3.0, 3.75, 4.5, 5.25, 6.0, 6.5, 7.0, 8.0, 9.0, 10.0. These mesh sizes correspond to those used for spawning stock assessment by the Maryland Department of Natural Resources. The order of the panels was determined by a randomized stratification scheme. The mesh sizes were divided into two groups, the five smallest and the five largest mesh sizes. One of the two groups was randomly chosen as the first group, and one mesh size from that group was randomly chosen as the first panel in the net. The second panel was randomly chosen from the second group, the third from the first group, and so forth, until the order was complete. The order of the panels in the first net was (in inches) 8.0, 5.25, 9.0, 3.75, 7.0, 4.5, 6.5, 6.0, 10.0, and 3.0, and the order was (in inches) 8.0, 3.0, 10.0, 5.25, 9.0, 6.0, 6.5, 3.75, 7.0, and 4.5 in the second net.

Striped bass collected from the monitoring sites were measured and weighed on a Limnoterra FMB IV electronic fish measuring board interfaced with a Mettler PM 30000-K electronic balance. The board records lengths (FL and TL) to the nearest mm, receives weight input from the balance, and allows manual input of sex and gonad maturity into a data file for subsequent analysis. Scales were collected from between the spinous and soft dorsal fins above the lateral line for subsequent aging, using the method established by Merriman (1941), except that impressions made in acetate sheets replaced the glass slide and acetone. All readable scales were aged using the microcomputer program DISBCAL of Frie (1982), in conjunction with a sonic digitizer-microcomputer complex (Loesch et al. 1985). Growth increments were measured from the focus to the posterior edge of each annulus. In order to be consistent with ageing techniques of other agencies, all striped bass were considered to be one year older on 1 January of each year.

Catch rates (kg/day and number/day) and age composition of the gill nets and pound nets were examined for evidence of sampling bias and appropriate data pooling. Age and size compositions were compared with the non-parametric Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981). If the largest unsigned difference between cumulative frequency distributions exceeded a critical value (D, the K-S statistic) for a given sample size and probability level ($p<0.05$), the null hypothesis (H_0: striped bass captured in either gear were taken from a population with the same age or size distribution) was rejected. Mean age was determined by the sum of the relative contribution of each age class to the total (aged) catch.

Estimates of survival (S, the fraction surviving after becoming fully recruited to the stock) were calculated by dividing the catch rate (number/day) of a year class in year a+1 by the catch rate (number/day) of a year class in year a. If the survival estimate between successive

years was >1, the estimate was derived by interpolating to the following year. The geometric mean of S was used to estimate survival over periods exceeding one year (Ricker 1975).

The spawning stock biomass index (SSBI) for striped bass was defined as the spring mean CPUE (kg/net day) of mature males (age-3 years and older), females (age-4 years and older) and the combined sample (males and females of the specified ages). Annual differences in the length (starting date and duration) and temperature regimes of each sampling season were examined. Following these comparisons, temporal criteria were established to allow comparison among rivers and years.

Results

Rappahannock River: Spring 1998

Pound nets: Striped bass (n= 817) were sampled between 9 March and 30 April 1998 from the three pound nets on the Rappahannock River. The 1994 (age-4) and 1995 (age-3) year classes were dominant, constituting 45.2% and 26.2% of the total, respectively (Table 2). Males made up 85.5% of the total catch. Males dominated the 1994-1998 year classes (98.9%) while females (Table 3) dominated the 1984-1989 year classes (98.8%). The contribution of males age-5 and older (the pre-1994 year classes) was only 9.3% of the total aged catch and 11.0% of the total males caught. These year classes were most vulnerable to commercial and recreational exploitation within Chesapeake Bay.

Overall, catches of both male and female striped bass were highest in the pound net farthest upriver (mile 47), due mainly to the large catches of predominantly young males in March and one exceptionally large catch of females on 16 April (Table 4). Catches were lowest at the pound net farthest down-river (mile 44). The proportion of females was highest in the pound net at mile 44 (20.7%) and lowest in the net at mile 47 (11.9%). The pound net at mile 44 also contained many of the oldest females captured. The age composition of males and females were almost identical in the three pound nets although more age-9 and age-10 females were taken in the pound nets at miles 44 and 46 (Fig. 3).

Although the highest overall catches of striped bass were observed in March, the annual spawning migration was marked by the increased abundance of pre-1990 year class fishes (predominantly female) during April (Table 3). The ratio of the male catch rates to female catch rates (kg/day) decreased from 1.9:1 early in the sampling period to 0.9:1 at the end of sampling (Table 4). There were two periods of increased abundance of female striped bass: the first occurring from 2-9 April and the second, and higher, from 16-20 April. The mean age of the female striped bass captured from 2-20 April only varied from 9.0-9.6 years, but reached a maximum of 11.7 years on 23 April (Table 4). By contrast the mean age of male striped bass increased from 3.3 years on 9 March to 4.2 years on 9 April, but only varied from 3.8-4.2 years

thereafter. Due to the increased prevalence of the larger females, the highest catch rates by weight occurred during April, peaking sharply on 16 April (Table 4).

Experimental gill nets: A total of 603 striped bass was sampled in the two variable-mesh experimental anchor gill nets between 9 March and 30 April. As observed in the pound nets, the 1994 (54.2%) and 1995 (23.4%) years classes were dominant (Table 5). The oldest striped bass (the 1985 and older year classes) were absent in the gill net samples, although present in low numbers in the pound net samples. Males were more abundant, constituting 95.2% of the total catch. Males dominated the 1994-1996 year classes (99.4%) and the 1990-1993 year classes (85.0%), but all 1989 and older year classes of striped bass were female (Table 6). The contribution of 1993 and older year classes of males was 14.5% of the total aged catch.

Catchability of striped bass in the two gill nets differed (Table 7). More fish were captured in net No. 2 (n= 432 striped bass) than in net No. 1 (n= 171). The differences in the catches resulted from exceptionally large catches of male striped bass in net no. 2 on 30 March and again on 13 April (Fig. 4). These catches produced widely divergent male to female ratios between the two nets (28:1 in net No. 2; 11:1 in net no. 1). Catches of males in each net had identical mean ages (Table 7) and age compositions (Fig. 5). Catches of females in each net had nearly identical mean ages (Table 7), but there was a peak in nine and 10-year old fish in net No. 2 that was absent in net No.1 (Fig. 5).

The mean age of the female striped bass captured from the gill nets was two years younger than that estimated for those captured in the pound nets, illustrating a relative scarcity of older (age-8+) females in gill-net catches. Only ten age-8+ females were captured in gill nets, and seven of these were taken from 2-9 April. The remaining females were captured in March.

Catchability of male striped bass (especially the 1994 and 1995 year classes) was highest in the 3.75- and 4.50-inch mesh panels of both gill nets (Tables 8 and 9) while the females were taken in the 5.25-inch and larger-mesh panels. Only six striped bass, all males, were captured in the 3.0-inch mesh panel, and no striped bass were captured in the 10.0 inch mesh panel.

Rappahannock River: 1993-1998 Summary

Annual Variation in Sampling Times and Effort: The start date and duration of the sampling seasons were variable each year (Table 1). Seasons commenced as early as 9 March, in 1998 and as late as 7 April, in 1994. Seasons ended as early as 21 April, in 1997 and as late as 3 May, in 1993. The total duration (in days) of each annual sampling period varied from 22-53 days for pound nets and 39-53 days for experimental anchored gill nets (Table 1). Each year, commercial pound nets were constructed and set according to the judgement of individual fishermen of local climate (especially the threat posed by ice or by spring floods) and market conditions. Similarly, once pound nets were established, the selection of an individual pound net

for sampling was subject to the individual fisherman's judgement of tide, weather and market conditions. In this case, these judgements altered the number of nets fished on any given day and the length of time each net was fished. As a result, the effort associated with pound net samples varied from 48-168 hours. In contrast, the multi-mesh, experimental gill net was a fishery independent gear, and effort was uniformly 24 hours.

Constraining the Analysis to a Restricted Sampling Window: To facilitate comparisons between years, we constrained the analysis to a temporal window of 30 March - 3 May in each year. Annual comparisons of catch rates by both gears are depicted in Figures 6 and 7. Throughout most of the six-year sampling period, there was a pattern of elevated catches of female striped bass that usually began in late March and peaked in mid- to late April. This period was characterized by a 5 °C range in water temperature (11-16°C, except in 1996 when water temperatures remained below 10°C until the middle of April). For the pound nets, the restricted sampling window encompassed the bulk of the catches of mature females and eliminated consideration of catches by the third net that was added in 1997 (Figure 6). By restricting the sampling window, fewer fish were considered in the analysis (38% fewer males and 16% fewer females) and fewer days were used in the computation of annual mean catch rates. Thus, using the restricted sampling window elevated catch rates and mean age of both sexes compared to using all available data from the entire season (Table 10). The increase in the mean ages resulted from the reduction in the relative contribution of the resident 2 to 4-year old striped bass that were usually prevalent in March (Fig. 8). As expected, Kolmogorov-Smirnov (K-S) two-sample tests ($\alpha = .05$) rejected the hypothesis that the age composition of male striped bass captured during the restricted season was taken from a population with the same age distribution as those captured during the entire season. However, in similar comparisons, the same hypothesis for female age composition was not rejected.

For the experimental gill net catches, the restricted sampling window also encompassed most of the catches of striped bass except in 1995 when catches were higher in March (probably due to an early warming trend) than observed in other years (Figure 7). As with the pound net data, by restricting the sampling window in the analysis of gill net catches, fewer fish were considered in the analysis (17% fewer males and 18% fewer females) and fewer days were used in the computation of annual mean catch rates. Catch rates and mean age of both sexes were elevated, compared to using all the data collected during the entire season (Table 11). The 1995 results were the most affected (53% fewer males and 43% fewer females; an increase in the mean age of males of 0.4 years and a 0.9 year increase in the age of females). As with the pound net data, the increase in the mean age resulted from the decrease in the relative contribution of 2-4 year old striped bass (Fig. 9) but K-S tests did not reject the hypothesis that the age composition of either sex captured during the restricted season was taken from a population with the same age distribution as those captured during the entire season

Variation in catch rates and age composition among pound nets: There were pound net-specific differences in seasonal catch rates (Table 12). Catch rates of both sexes in the upriver pound net (mile 47) were always higher than that of the downriver net (mile 44). In some years, upriver catch rates were 2-6 times those of the downriver net. The introduction of a third pound

net (mile 46) in an intermediate position on the river in 1997 yielded catches of females that were similar to the upriver net.

The mean age of both sexes captured in the downriver net was usually greater than that of striped bass captured in the upriver pound net (Table 12). The age composition of both sexes was generally similar in both nets during most years (Figures 10 and 11). For males, more age-5 fish were taken in the downriver net in 1993; more age-3 and age-4 fish were captured in 1996, and older fish (>8 years) were captured in1994 (Fig. 10). For females, more age-5 and age-6 fish were taken in the upriver net in 1993, and more age-5 to age-11 fish were captured in 1995-1996 (Fig. 11). It should be noted that all pound nets were not sampled on a same date. Thus, the observed differences in age composition and catch rates were likely due to a combination of factors, including variation in sampling date and catchability of each pound net.

Variation between gill nets: There were also net-specific differences in seasonal catch rates of the two multi-mesh gill nets during the six years of sampling. Catch rates of both sexes were usually higher in no.1, especially of male striped bass (Table 13). For males, catch rates by net No.1 exceeded catches from net No. 2 in four of the six years (1993, 1995-1997). In those years, catches by net No.1 were 1.3-8 times the catches of males in net No. 2. For females, catch rates by net No.1 were higher in 1993, 1995-1997. However, the magnitude of these differences was not large (Table 13). The mean ages of both male and female striped bass captured in both gill nets were almost identical during for the six year period (Table 13).

Panel-specific differences in catches: The susceptibility of striped bass varied widely with mesh size. Mean age and size of both sexes increased with increasing size of the mesh. Male striped bass, mostly age six and younger, were most vulnerable to the 3.0-, 3.75-, 4.5- and 5.25-inch meshes (Table 14). These four mesh sizes accounted for 92.4% of the number of all males captured, and accounted for 82.7% by weight. The catches in the 4.5- and 5.25-inch mesh panels corresponded with the 18-22 inch total length (457-559 mm) striped bass that provided the bulk of the commercial harvest. The 8.0-10.0 inch-mesh panels captured only 5.4% of male striped bass. Catches of female striped bass were highest in the 6.0 - 8.0 inch mesh panels, 62.0% by numbers and 72.5% by weight. The mean size of striped bass captured from these panels exceeded the 28-inch (709 mm) minimum total length allowed for harvest in coastal Atlantic Ocean waters.

Variation in age composition between gears: Comparisons of the age structure of the catch from the pound nets and gill nets are depicted in Figures 12 and 13. Both gears exhibited a temporal trend towards a younger age structure for males with smaller proportions of older males (age-6 and older) captured in 1997-98 (Figure 12). Mean age of males sampled from the pound nets was lowest in 1995 (3.3 years), and remained steady thereafter at about 4.0 years (Table 10). During the period, the proportion of age-5+ males decreased from 42% to 13%. Similarly, the mean age of males sampled from the gill nets decreased from 4.9 to 4.0 years (Table 11). Kolmogorov-Smirnov two-sample tests ($\alpha = .05$) accepted the hypothesis that the age composition of males captured by pound nets was taken from a population with the same age distribution as those captured by gill nets in all years except in 1995. For females, both gears

exhibited a distinct temporal trend towards an older age structure, with larger proportions of older females (age-9 and older) taken in 1997-98 (Figure 13). Mean age of females from the pound nets increased from 6.9 to 9.4 years (Table 10). During the period, the proportion of age-7+ females increased from 9% to 24%. The mean age of females taken in gill nets increased from 6.3 to 8.0 years from 1993-1996, but was only 7.0 years in 1998 (Table 11). Kolmogorov-Smirnov two-sample tests ($\alpha = .05$) rejected the hypothesis that the age composition of females captured by pound nets was taken from a population with the same age distribution as those captured by gill nets in all years except in 1995.

Assessment of the spawning stocks: Catch rates (numbers of fish/day) of year classes (sexes combined) sampled in both gears are presented in Tables 15-16. Cumulative annual catch rates (all year classes combined) in pound nets were about 14 fish/day except in 1993 and 1997 when catches were somewhat higher (Table 15). For gill nets, annual mean catch rates of all year classes combined varied from 34 to138 fish/day with the highest rates observed in 1997 and the lowest in 1995 (Table 16). The youngest (1995-96) and oldest year classes (1986 and older) were not well represented in the samples (Tables 15-16). The largest abundances by age class in both gears occurred at age-3 through age-6. The 1988 and 1989 year class were strongest in the gill nets samples and the 1988 year classes was strongest in the pound nets samples. The combined data (both sexes and both gears) indicated that six year classes (1987-89 and 1992-94) were strong contributors, and that two year classes (1990, 1991) were weak contributors to the spawning stocks during the sampling period.

Catch rates (numbers of fish/day) of year classes of males sampled in both gears are presented in Tables 17-18. Cumulative annual catch rates (all year classes combined) in the pound nets were relatively steady during the sampling period but were more variable in the gill nets. The highest cumulative annual catch of males was observed in 1997 (134 fish/day, Table 18). The highest catch rate from both gears was at age five in 1993 and 1994, age three in 1996 and age four in 1997 and 1998 (Tables 17 and 18). The combined data (both gears) indicated that five year classes of males (1988-89 and 1992-94) were strong contributors and two year classes of males (1990-91) were weak contributors to the stocks during the 6-year period.

Catch rates (numbers of fish/day) of year classes of females sampled in both gears are presented in Tables 19-20. Cumulative annual catch rates (all year classes combined) in both gears declined during the sampling period. The highest abundances by age class in both gears occurred at age-five through age-seven with peak catches observed for age-six females in both gears in 1993 (the 1987 year class). In both gears, the 1987 and 1988 year classes of females were the major contributors to the spawning stocks during the sampling period.

Plots of catch-at-age for eight year classes of striped bass (1987-1994) captured in pound nets and multi-mesh gill nets during the 6-year period are depicted in Figures 14 and 15. Catch rates of males usually declined sharply after fully recruiting to the pound nets at age four or five (Fig. 14) or to the gill nets at age-three to age-five (Figure 15). Catches of females usually exhibited initial peaks at age-five or age-six. For both sexes, catch curves revealed secondary peaks in abundance following the initial peak in pound net catches, especially for year classes

(1987-1989) that were tracked by the monitoring program for the longest period. For males in these year classes, secondary peaks were observed at age-six (1987 year class), and age-seven to age-eight (1989 year class). For females, these secondary peaks were higher and observed at age-nine to age-ten in year classes 1987-1990 (Figure 14).

Yearclass-specific estimates of annual survival (S) were usually higher from the pound net data than from the gill net data (Tables 21-26). Survival estimates of striped bass captured from the pound nets (both sexes) varied from 0.56-0.75 for the 1983-1991 year classes, but was as low as 0.20 for the 1992 year class (Table 21). Survival estimates of striped bass captured from the gill nets (both sexes) varied from 0.33-0.61 for the 1986-1991 year classes but were less than 0.10 for the 1992 and 1993 year classes (Table 22).

There were widely divergent survival estimates between the sexes. Survival of male striped bass was less than 0.4 in every year class from both gears, except for the 1991 year class, as estimated from pound net data (Tables 23 and 24). The survival estimates of age-4 males captured in pound nets since the fishery re-opened in 1993 were 0.45 and 0.18 for the 1992 and 1993 year classes, respectively (Table 23). The survival estimate of age-5 males was similar in both gears, and declined from 0.54 to 0.04 from 1994-1998. Survival estimates of females from the pound net data varied from 0.61-0.91 for the 1983-1991 year classes but was as low as 0.36 for the 1992 year class (Table 25) .

Spawning Stock Biomass Indexes (SSBI): The highest SSBI for both sexes combined was observed in 1997 in both gears (Table 27). During the 6-year period, values of the SSBI for both sexes combined were above average in 1993-94 and 1997-98 in pound nets; values were above average in 1993-94 and 1997 in gill nets. The peak index for males was in 1993 and 1997 for pound nets and gill nets, respectively. The highest SSBI for females was observed in 1997 and 1993 for pound nets and gill nets, respectively.

The trend of declining values of SSBI for females from 1993-1996 were similar for both gears (Table 27). This trend continued in 1997 and 1998 in gill nets but female SSBI increased in pound nets during 1997-98. This difference was due to an upward shift in the relative number of heavier (older) females that were not taken in the gill nets in recent years.

James River: spring 1998

Experimental gill nets: Striped bass (n= 236) were collected between 9 March and 30 April 1998 in two variable-mesh anchored gill nets. The 1994 (age-four) and the 1993 (age-five) year classes were numerically dominant, constituting 30.5% and 28.8% of the total number taken, respectively (Table 28). The 1992 and 1993 year classes contributed 17.1% 15.1% of the total weight, respectively (Table 28). The total catch was 69.5% male and 30.5% female. Males dominated the 1994-1995 year-class group (96.6%) and the 1990-1993 year-class group, but 92.6% of the oldest striped bass (1989 and older) were female (Table 29).

Catchability of striped bass in the two anchored gill nets differed (Table 30). More fish were captured in net No. 1 (n= 161) than in net No. 2 (n= 75). The differences were due in part to larger catches of males in net No. 1 on 2 April and on 9 April. There was little difference in the total number of females taken by either net (n= 36 in net No.1; n= 30 in net No. 2). Overall, the mean age of the females captured in net No. 1 was slightly higher (Table 30). The largest proportion of the catch of female striped bass (90.3% of the total) was taken between 30 March and 30 April, with peaks in abundance on 2 April and 20 April (Figure 16). Both nets captured similar proportions of males ages three-seven, but the oldest males were captured in net # 2 (Figure 17). Both nets captured females that were ages four-eleven but age-five, age-six and age-nine females dominated the catch of net No. 2 while age-five females were most abundant in net No. 1 (Figure 17).

Males dominated the catch in the 3.0- to 5.25-inch mesh panels of both nets and accounted for 75.6% of all males captured (Tables 31 and 32). The 8.0- to 10.0-inch mesh panels captured 94.1% of all females, while both sexes were taken in relatively equal proportions (males, 53.1%; females, 46.9 %) in the 6.0- to 7.0-inch mesh panels. The highest catch rates (kg/day) in net No. 1 were observed in the 4.5-inch panel (due to the high concentration of males) and in the 7.0-inch panel. In net No. 2, the maximum catch rates were observed in the 6.0- and 6.5-inch panels (Tables 31-32).

James River: 1994-1998 Summary

Variation among sampling seasons: The start date and duration of the sampling seasons were variable, beginning as early as 27 February in 1995 and as late as 21 March in 1996. Seasons ended as early as 27 April in 1995 and as late as 9 May in 1994 (Table 1). Fyke nets were usually sampled concurrently with the gill nets in each season. Effort associated with the fyke nets were usually three or four days, except in 1994 when 24-h sets were used to compare catches by fyke and gill nets. Gill net samples were 24-h sets each year.

The temporal pattern in catches of female striped bass from the fyke nets and the gill nets was usually similar within years (Figures 18-19). Catches of females were usually concentrated in the period 27 March through 1 May in every year. In 1994 and 1995, there was an earlier, smaller peak in abundance in the period of 23-28 March in both gears (Figures 18-19). The highest catch rates of females in the fyke nets occurred from 25 April - 3 May in 1994-1996 and 10-17 April in 1997. In all years except 1998, the highest catch rates of females in gill nets occurred from 8-29 April (Figure 19).

As with the Rappahannock River data, we constrained the analysis of James River data to a temporal window of 30 March to 3 May to facilitate comparisons between years. These dates encompassed the bulk of the elevated catches associated with the migration of female striped bass into the spawning grounds. By restricting the sampling window, fewer fish were considered in the analysis (fyke nets: 17.7% fewer males and 15.0% fewer females; gill nets: 23.1% fewer males and 13.5% fewer females) and fewer days were considered in the computation of annual mean catch rates. The restricted sampling window produced little change in mean ages for either sex (Tables 33 and 34, Figure 20). Kolmogorov-Smirnov (K-S) two-sample tests accepted the

hypothesis that the age composition of striped bass (both sexes) captured during the restricted season was taken from a population with the same age distribution as those captured during the entire season.

Variation between fyke nets

There were net-specific differences in fyke net catches. In 1995 and 1996, the total catches of male striped bass were much higher in fyke net No. 1 than in fyke net No. 2, but were equal in 1997 (Table 35). The total catches of female striped bass were slightly higher from fyke net No. 2. Male striped bass were younger in 1995 and 1996 in fyke net No. 1 (Figure 21). In contrast, females were younger in fyke net No. 2 (Figure 21). Kolmogorov-Smirnov two-sample comparisons rejected the hypothesis that the age composition of males captured in both nets was taken from a population with the same age distribution in 1995 and 1997. Comparison of the annual age structures of female striped bass indicated no significant differences between nets. For both sexes, the fyke net with the fewer fish also was the net with the largest fish. The reduced catches of both sexes in both nets in 1997 were at least partially result of a deterioration in the condition of the fyke net, prompting the decision to terminate the use of fyke nets as a non size-selective comparative gear in the James River.

Variation between gill nets

There were only modest differences in the catches between the two experimental anchored gill nets. Overall total catches of both male and female striped bass were higher from gill net No. 1 than from net No. 2 (Table 36). The total catches of males were higher from net No. 1 in every year except 1995 and the total catches of females were higher in every year except 1997, but only in 1998 was there a large disparity in catches between the two nets. Moreover, the overall mean age of the female striped bass was higher in net No. 2, by as much as 1.3 years in 1995, so that the overall mean catch rate of gill net No. 1 was only slightly high than for net No. 2 for both sexes. The total number of striped bass yearly was relatively low, especially for the older age classes, so the data of the two nets were pooled for assessment of the spawning stock.

Panel-specific differences in catch

The total catch of striped bass was highest in the 4.5-inch mesh panel, while the highest catch rate was in the 6.5-inch mesh panel (Table 37). Male striped bass were concentrated in 3.75- to the 5.25-inch mesh panels. These panels contained 72.8 % of the total males captured, had a ratio of males to females of 4.24:1, but produced only 54.5% of the total male biomass. Females were concentrated in the 6.0- to 7.0-inch mesh panels, making up 54.2 % of the total captured, and containing 54.3% of the total female biomass. The catch of the 8.0- to 10.0-inch mesh panels was 88.0% female, and contained 19.3% of the total biomass.

Assessment of the spawning stocks

The trend in the age structures of both male and female striped bass in the James River was toward an older, more age-diverse population. Males captured in 1994 comprised only four age classes (ages three to six) while in 1998, eight age classes were captured (Figure 22). During this time, the mean age increased from 4.4 to 4.7 years (4.9 years in 1997), and the contribution of age seven and older males increased to 10%. Females captured during the period 1994-1998 comprised ages nine and ten (Figure 22). The mean age of females increased from 6.5 to 7.5 years (7.8 in 1997) as the contribution of females age eight and older increased from 27% in 1994, 56% in 1997, and 46% in 1998.

The annual mean catch rates (number of fish/day) were much higher in 1994 and 1995 than in 1996-1998 (Table 38). Peak abundance by age class occurred at age four or five in each year from 1994-1998. The data indicate that the 1989 and 1990 year classes were the strongest, and the 1992 year class the weakest through the period.

The cumulative catch rates (number of fish/day) of males was highest in 1994 and 1995, lowest in 1996 and 1997, and higher again in 1998 (Table 39). The peak catch rates of male striped bass was highest at age four in every year except age five in 1996. The data indicate that the 1990 year class was strongest and the 1992 year class the weakest. The cumulative catch rate of age seven and older males reached a maximum of 1.9 in 1997. These age classes contributed 16.0% of the total catch rate in 1997, but 11.0% or less in other years.

The cumulative catch rate of females (number of fish/day) reached a maximum of 22.6 in 1995, but only varied from 6.7 to 7.4 from 1996-1998 (Table 40). The most abundant age group of females was age five in 1994 and 1998, and age nine in 1997. The data indicate that the 1989 and 1990 year classes were strong and the 1991 and 1992 year classes weak. The peak in females that were age nine in 1997 was probably the result of the weak recruitment of the 1991 and 1992 year classes during that year of sampling. The cumulative catch rate of age eight and older females was highest in 1995 (6.4 fish/day), but varied from only 2.9-3.6 fish/day in the other years. The relative contribution of these age classes rose from 29.0 % in 1994 to 53.3% in 1997, then declined to 44.6% in 1998.

Although the James River time series is less extensive than that for the Rappahannock River, catch curves of the 1987-1994 year classes depict discernable trends. Males show a steep decline in abundance after age five and disappear from the fishery by age nine (Figure 23). Female striped bass also show a steep decline from ages five to seven, but show a secondary peak of age nine and older fish.

Year class-specific estimates of annual survival derived from the annual composite age structures varied widely. The estimates of the 1989-1991 year classes, which encompassed similar age classes, varied from 0.50-0.57 (Table 41). Survival estimates of 1989-1991 male striped bass ranged from 0.28-0.55 (Table 42) while those of female striped bass ranged from

0.49-0.87 (Table 43). The high catch rate in 1995 relative to the other years resulted in low estimates of survival for most year classes the subsequent year and depressed the overall survival rates.

Spawning Stock Biomass Index

The Spawning Stock Biomass Index for striped bass in the James River peaked for both sexes in 1995, was above average in 1994 and has slowly increased from its lowest values in 1996 (Table 43). The increase in the mean weight of the females was reflected in the 7.2% increase in the female SSBI despite a 12.2% reduction in the total number of females captured. In contrast to the gill net SSBI of the Rappahannock River, female striped bass biomass exceeded the male biomass in every year.

Both Rivers: Comparison of Spawning Stock Biomass Index calculated from gill net catches

During 1995-1998, values of the SSBI (both sexes combined) were higher on the Rappahannock River except in 1995 (Tables 27, 44). Values of the index were consistently higher for females on the James River. Values of the index for males was higher on the Rappahannock River except in 1995.

Discussion

Striped bass stock had recovered sufficiently by 1993 to allow the re-establishment of limited commercial and recreational fisheries in Virginia. The monitoring efforts summarized in this report were intended to document changes in the abundance and age composition of spawning stocks in the James and Rappahannock rivers during the period of selective harvest by these fisheries.

The main advantages of pound nets is that the gear provides large catches (often in excess of 100 fish per date) that are presumably not sex- or size-biased. However, the commercial pound nets that we sampled in the Rappahannock River had different fishing characteristics, and our sampling methods may have introduced additional variability. The down-river net (mile 44) was set in a shallow, flat-bottomed portion of the river with a leader that extended farther into the bay. The upriver net (mile 47) was set in a constricted portion of the river that abutted the channel, and had a leader that extended almost to the shoreline. Total catches from the upriver net were usually (but not always) higher than from the down-river net. Ideally, each net was sampled weekly, but uncontrollable factors (especially tide, weather and market conditions) affected this schedule. Thus, in some years (1993 and 1996) the down-river net was under-sampled. In addition, weekly sampling occurred each Monday and Thursday, a schedule that translated to fishing efforts of 96 hrs (Thursday through Monday) or 72 hrs (Monday through Thursday). When conditions prevented fishing on either scheduled day, effort

could be extended up to 196 hours if the fisherman waited for the following scheduled sampling date. Although these events were rare, we were unable to assess whether or not they influenced estimates of catch rate.

Effort was more easily regulated in the fyke nets used in the James River. However, these small fishing structures often became filled with catfish (Ictaluridae) during the 72- or 96-hrs period. We expect that gear saturation by catfish might have affected catch rates of striped bass. Furthermore, the overall condition of the nets also declined over time, and probably resulted in a lower catches in 1997.

Variable-mesh gill nets were set by commercial fishermen and fished by scientists after 24 h on designated sampling days. As a result, there were fewer instances of sampling inconsistencies. The two nets were set approximately 100 meters apart and along the same depth contours on both rivers. Although the down-river net did not always contain the greater catches, removal by one net may have affected the catch rates of its companion.

The gill net captured proportionally more males than did the pound nets or the fyke nets. Anecdotal information from commercial fishermen suggests that spawning males are attracted to con-specifics that have become gilled in the net meshes. Thrashing of gilled fish may emulate spawning behavior (termed "rock fights" by local fishermen) and enhance catches of males.

The pound net catches contained a greater relative proportion of older female striped bass than did the catches from the gill nets. Differences in age composition between pound nets and gill nets were statistically significant or females but not males. Thus, given the presence of large females in the spawning run, it is clear that the gill nets do not adequately sample large (1000+ mm FL) striped bass.

The biological characterization of the spawning stock of striped bass in the Rappahannock River changed dramatically from 1993-1998. There was a steady decrease in the relative abundance of five to seven year-old males and the mean age of males decreased by one year. These age classes are targeted by the recreational and commercial fisheries. Current regulations protect females from harvest during their annual migration by higher minimum lengths in the coastal fishery (711 mm TL vs. 458 mm TL within Chesapeake Bay) and the closure of the fishery in the bay during the April spawning run. Our monitoring data depict increasing abundance of female striped bass >10 years old through the period, and an increase in their mean age of about 2.5 years.

In our analysis of catch rates, we observed a distinctive bimodal distribution in the 1987-1989 year classes. These striped bass appeared in greatest abundance at age five or six, at lower abundance at age six to eight, and then higher abundance at ages nine to12. Age estimation of larger striped bass by scales is problematic because of re-absorption or erosion of outer margins of scales may cause under-estimation of age. Thus, under-ageing errors might tend to lump catches of old fish (>12 years) into younger categories (nine to 12 years). However, ignoring age, we also observed a bimodal size distribution, one group from 470-590 mm fork length,

presumably young, and the second group of 850-1200 mm fork length, presumably older. This trend became increasingly apparent in the 1997 and 1998 data and its significance has not been determined.

The time series of the catch rates by age class and by year class indicate that the age of peak abundance in the rivers has changed from five or six years in 1993 and 1994 to three to five years in 1998. Changes in the annual catch rates by year class in the Rappahannock River indicated that strong year classes occurred in 1988, 1989, 1993 and 1994, and weak year classes occurred in1990 and 1991. Likewise the data for the James River indicated that strong year classes occurred in 1988-1990, and weak year classes occurred in 1991 and 1992.

The time series allows estimates of survival of the year classes using catch curves, especially for the 1987-1990 year classes that were captured for four or five years subsequent to their peak in abundance at age four or five. The survival estimates of female striped bass of these year classes in the Rappahannock River were approximately 0.85 in pound nets and 0.60 in gill nets. The lower capture rates of larger (older) females in the gill nets resulted in lower estimates. The survival estimates of male striped bass were approximately 0.38 in pound nets and 0.30 in gill nets. The large differences between the sexes may reflect a management strategy that targets males. The high survival estimates for the females may the result of their differential maturation rates. These differences may cause lower peaks in abundance (usually at age five) as only fractions of each year class mature. Similarly, survival estimates for these year classes in the James River were highly variable, ranging from 0.49-0.74 for females and from 0.28-0.53 for male striped bass.

The values of the Spawning Stock Biomass indexes (SSBI) in the Rappahannock River were not consistent between pound nets and gill nets. Based on pound net catches, the highest values of male and female biomass were in 1993 and 1997, respectively. For the gill net data, the highest value of male biomass was in 1997. Due to the highly selective nature of the gill nets (significantly fewer large females), the female SSBI is unreliable. Female biomass rebounded in the pound nets in 1997 and 1998. The high values in 1993 and 1997 were such that most the other values were below the six-year mean. The low values in 1996 are probably an underestimate of spawning stock strength since water temperatures were below normal in that year, and the spawning migration probably continued past the end of sampling.

The values of the SSBI in the James River were highest in 1995 and have slowly increased from the lowest values that were estimated for 1996. The below normal water temperatures noted for the Rappahannock River in 1996 apply to the James River as well and probably produced a similar under-estimation of spawning stock abundance. The scarcity of larger striped bass from the gill nets in the James River implies a similar limitation in fishing power as shown in the Rappahannock River but comparative data are not available since there are no commercial pound nets on the James River.

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Table 1. Duration of the sampling seasons for striped bass spawning stock assessment on the James and Rappahannock rivers by gear, spring 1993-1998. The total numbers of days encompassed by each sampling period for each gear is given in parentheses.

Year	James River		Rappahannock River	
	Fyke net(s)	**Gill net(s)**	**Pound nets**	**Gill nets**
1993	not sampled	not sampled	30 Mar-3 May (35)	22 Mar-6 May (46)
1994	7 Mar-9 May (64)	7 Mar-9 May (64)	7 Apr-28 Apr (22)	21 Mar-28 Apr (39)
1995	27 Feb-24 Apr (57)	27 Feb-27 Apr (60)	13 Mar-24 Apr (43)	6 Mar-27 Apr (53)
1996	21 Mar-6 May (47)	21 Mar-6 May (47)	25 Mar-2 May (39)	25 Mar- 7 May (44)
1997	10 Mar-28 Apr (50)	10 Mar-28 Apr (50)	13 Mar-21 Apr (40)	10 Mar-21 Apr (43)
1998	not sampled	9 Mar-30 Apr (53)	9 Mar-30 Apr (53)	9 Mar-30 Apr (53)

Table 2. Mean fork length (mm), weight (g), standard deviation (SD) and CPUE (fish per day; weight per day), of striped bass from pound nets in the Rappahannock River, spring 1998.

Year Class	Sex	n	Fork Length Mean	Fork Length SD	Weight Mean	Weight SD	CPUE F/day	CPUE W/day
1984	female	2	1,170.0	35.4	17,619.7	1,388.2	0.0	749.8
1985	female	4	1,045.8	6.0	13,509.5	1,310.0	0.1	1,149.8
1986	female	7	1,005.3	23.2	13,179.4	1,590.3	0.1	1,962.9
1987	female	24	958.6	23.4	11,343.5	1,461.8	0.5	5,792.4
1988	female	25	900.9	24.5	9,298.5	918.9	0.5	4,946.0
1989	male	1	830.0		7,152.8		0.0	152.2
	female	20	846.0	23.8	7,766.7	897.6	0.4	3,305.0
1990	male	3	778.3	26.6	6,096.0	738.7	0.1	389.1
	female	16	787.5	26.4	6,386.7	678.8	0.3	2,174.2
1991	male	9	735.9	29.0	5,190.0	505.1	0.2	993.8
	female	6	705.8	17.6	4,483.3	539.1	0.1	572.3
1992	male	1	593.0		2,762.1		0.0	58.8
	female	1	568.0		2,713.0		0.0	57.7
1993	male	62	514.2	13.0	1,760.9	185.3	1.3	2,322.9
	female	4	519.3	7.3	1,826.6	137.5	0.1	155.5
1994	male	362	458.0	23.7	1,264.6	221.3	7.7	9,740.3
	female	7	492.6	20.4	1,642.9	234.9	0.1	244.7
1995	male	213	392.8	24.6	763.7	143.0	4.5	3,461.1
1996	male	38	284.0	31.7	305.7	94.7	0.8	247.2
N/A	male	9	497.4	117.8	1,786.2	1,685.4	0.2	342.0
	female	3	743.0	196.2	6,361.8	3,874.6	0.1	406.1

N/A- not aged

Table 3. Numbers of striped bass in three age categories (year classes 1994-1996, 1990-1993 and 1985-1989) in pound nets in the Rappahannock River by sampling date in spring 1998.

Date	n	Year Class							
		1994 - 1996		1990 - 1993		1984 - 1989		Not aged	
		M	F	M	F	M	F	M	F
9 March	112	103	1	8	0	0	0	0	0
16 March	60	56	1	3	0	0	0	0	0
19 March	39	34	0	4	1	0	0	0	0
23 March	106	98	1	7	0	0	0	0	0
26 March	99	92	0	5	0	0	2	0	0
2 April	23	6	1	1	4	0	10	1	0
6 April	56	35	0	5	3	0	11	2	0
9 April	40	17	1	4	5	0	12	1	0
13 April	15	5	0	3	1	0	5	0	1
16 April	90	51	1	10	7	0	19	0	2
20 April	69	40	0	7	4	1	15	2	0
23 April	29	18	0	3	0	0	7	1	0
30 April	79	58	1	15	2	0	1	2	0
Total	**817**	**613**	**7**	**75**	**27**	**1**	**82**	**9**	**3**

Table 4. Net-specific summary of catch rates and ages of striped bass (n= 817) in three pound nets on the Rappahannock River, spring 1998. Values in bold are grand means for each column.

Date	Net ID	n	CPUE (fish/day)		CPUE (g/day)		Mean age	
			M	F	M	F	M	F
9 March	S473	112	37.0	0.3	33,237.5	566.3	3.3	4.0
16 March	S462	60	8.4	0.1	9,491.6	239.5	3.6	4.0
19 March	S441	39	12.7	0.3	14,658.0	625.6	3.7	5.0
23 March	S473	106	26.3	0.3	28,891.5	283.6	3.6	4.0
26 March	S462	99	32.3	0.7	35,045.1	7,796.6	3.6	11.0
2 April	S473	23	2.7	5.0	3,397.0	44,415.2	3.9	9.2
6 April	S441	56	10.5	3.5	13,340.7	29,323.3	3.7	9.4
9 April	S462	40	7.3	6.0	11,348.8	49,564.6	4.2	9.6
13 April	S441	15	2.0	1.8	4,329.0	12,793.4	3.8	9.0
16 April	S473	90	20.3	9.7	30,800.1	86,986.7	4.1	9.4
20 April	S462	69	12.5	4.8	16,370.1	39,106.5	4.1	9.5
23 April	S441	29	7.3	2.3	7,532.4	29,602.8	3.8	11.7
30 April	S473	79	25.0	1.3	35,341.5	8,296.0	4.1	7.8
Totals	S441	139	7.9	2.1	9,803.6	18,510.6	3.7	9.7
	S462	268	13.4	2.4	15,947.3	18,716.8	3.8	9.5
	S473	410	22.5	3.1	26,493.4	26,370.4	3.7	9.0
Season			**14.9**	**2.5**	**17,494.6**	**21,516.3**	**3.7**	**9.3**

Table 5. Mean fork length (mm), weight (g), standard deviations (SD) and CPUE (number per day; weight per day) of striped bass from variable-mesh gill nets (all meshes combined) in the Rappahannock River, spring 1998.

Year Class	Sex	n	Fork Length		Weight		CPUE	
			Mean	SD	Mean	SD	F/day	W/day
1996	male	5	293.0	2.8	324.5	28.9	0.4	115.9
1995	male	141	394.4	20.1	774.5	109.8	10.1	7,800.3
1994	male	324	460.0	23.9	1,304.0	236.1	23.1	30,178.3
	female	3	497.3	16.8	1,763.3	320.6	0.2	377.9
1993	male	69	522.8	22.6	1,880.0	365.3	4.9	9,265.7
	female	6	556.0	21.7	2,467.6	284.1	0.4	1,057.5
1992	male	7	614.3	23.9	3,072.7	377.6	0.5	1,536.4
	female	2	597.5	5.0	2,638.7	201.8	0.1	377.0
1991	male	6	710.8	22.2	4,968.8	258.8	0.4	2,129.5
	female	6	697.7	21.0	4,558.0	715.4	0.4	1,953.4
1990	male	2	767.0	2.8	6,037.9	443.1	0.1	862.6
	female	1	750.0		5,316.1		0.1	379.7
1989	female	3	881.7	43.1	9,415.0	1,757.6	0.2	2,017.5
1988	female	3	935.7	50.6	11,599.7	3,769.9	0.2	2,485.7
1987	female	1	946.0		11,097.3		0.1	792.7
1986	female	2	994.0	29.7	13,542.3	3,232.0	0.1	1,934.6
N/A	male	20	476.4	64.9	1,509.7	687.9	1.4	2,156.7
	female	2	717.0	230.5	5,357.7	4,699.2	0.1	765.4

N/A- not aged

Table 6. Numbers of striped bass in variable-mesh gill nets in the Rappahannock River by date, sex, and year class in spring 1998.

Date	n	Year Class							
		1994 - 1996		1990 - 1993		1986 - 1989		Not aged	
		M	F	M	F	M	F	M	F
9 March	33	29	0	3	1	0	0	0	0
16 March	12	10	1	1	0	0	0	0	0
19 March	19	17	0	1	0	0	0	1	0
23 March	8	2	0	3	0	0	0	3	0
26 March	18	13	0	5	0	0	0	0	0
30 March	171	149	0	17	1	0	0	4	0
2 April	12	3	0	3	2	0	4	0	0
6 April	62	53	0	5	2	0	2	0	0
9 April	124	93	0	24	1	0	1	5	0
13 April	84	65	0	15	2	0	1	0	1
16 April	22	19	0	3	0	0	0	0	0
20 April	15	10	1	2	2	0	0	0	0
23 April	15	7	1	2	4	0	1	0	0
30 April	8	0	0	0	0	0	0	7	1
Total	**603**	**470**	**3**	**84**	**15**	**0**	**9**	**20**	**2**

Table 7. Net-specific summary of catch rates of striped bass in variable-mesh gill nets sampled from the Rappahannock River, spring 1998.

Date	Net ID	n	CPUE (count/day)		CPUE (g/day)		Mean age	
			M	F	M	F	M	F
9 March	GN # 1	21.0	21.0	0.0	23,628.1	0.0	3.4	—
	GN # 2	12.0	11.0	1.0	11,520.0	2,044.8	3.5	5.0
16 March	GN # 1	6.0	5.0	1.0	5,593.3	1,412.3	4.0	4.0
	GN # 2	6.0	6.0	0.0	5,677.2	0.0	3.3	—
19 March	GN # 1	10.0	10.0	0.0	10,478.3	0.0	3.7	—
	GN # 2	9.0	9.0	0.0	8,958.0	0.0	3.3	—
23 March	GN # 1	5.0	5.0	0.0	8,563.2	0.0	4.8	—
	GN # 2	3.0	3.0	0.0	4,020.0	0.0	—	—
26 March	GN # 1	10.0	10.0	0.0	13,026.7	0.0	3.9	—
	GN # 2	8.0	8.0	0.0	8,337.5	0.0	3.8	—
30 March	GN # 1	9.0	9.0	0.0	7,663.3	0.0	3.4	—
	GN # 2	162.0	161.0	1.0	210,542.3	5,152.0	3.9	7.0
2 April	GN # 1	6.0	1.0	5.0	3,007.5	49,339.7	6.0	8.8
	GN # 2	6.0	5.0	1.0	7,232.1	10,715.6	4.4	8.0
6 April	GN # 1	24.0	23.0	1.0	31,744.9	3,478.2	3.7	7.0
	GN # 2	38.0	35.0	3.0	43,173.9	26,112.6	4.0	9.7
9 April	GN # 1	53.0	52.0	1.0	142,441.0	7,415.5	4.0	9.0
	GN # 2	71.0	70.0	1.0	110,335.6	5,253.4	4.2	7.0
13 April	GN # 1	15.0	12.0	3.0	18,107.7	19,671.0	4.1	7.5
	GN # 2	69.0	68.0	1.0	92,681.9	2,183.3	4.1	5.0
16 April	GN # 1	1.0	1.0	0.0	2,688.9	0.0	6.0	—

	GN # 2	21.0	21.0	0.0	24,597.6	0.0	3.8	—
20 April	GN # 1	7.0	6.0	1.0	6,772.8	4,399.9	3.7	7.0
	GN # 2	8.0	6.0	2.0	6,667.2	4,396.3	3.7	4.5
23 April	GN # 1	2.0	0.0	2.0	0.0	4,635.4	—	4.5
	GN # 2	13.0	9.0	4.0	12,690.1	21,633.5	4.2	7.5
30 April	GN # 1	2.0	2.0	0.0	3,867.4	0.0	—	—
	GN # 2	6.0	5.0	1.0	9,617.0	2,034.9	—	—
Totals	GN # 1	171.0	11.2	1.0	19,829.5	6,453.7	3.9	7.3
	GN # 2	432.0	29.8	1.1	39,717.9	5,680.5	3.9	7.2
Season		**603.0**	**41.0**	**2.1**	**58,547.4**	**12,134.2**	**3.9**	**7.3**

Table 8. Mean fork length (mm), weight (g), standard deviation (SD) and CPUE (fish per day; weight per day) by year class and sex per panel of striped bass captured in variable-mesh gill net #1 in the Rappahannock River, spring 1998.

Mesh size	Year class	Sex	n	Fork length		Weight		CPUE	
				Mean	SD	Mean	SD	Fish/D	Weight/D
3.00	1996	M	3	293.3	3.1	341.8	22.4	0.2	73.0
3.75	1995	M	40	394.4	16.4	768.4	98.5	2.8	2,189.0
	1994	M	37	444.8	24.8	1,162.2	243.8	2.6	3,062.3
	1993	M	4	515.5	26.2	1,763.9	385.4	0.3	502.5
	1992	M	1	599.0		3,007.5		0.1	214.2
	1988	F	1	890.0		8,291.1		0.1	590.5
	N/A	M	6	466.5	60.7	1,364.9	518.5	0.4	583.2
4.50	1995	M	15	388.9	23.7	750.9	105.4	1.1	802.2
	1994	M	17	451.6	24.1	1,193.7	231.8	1.2	1,445.2
		F	1	478.0		1,412.3		0.1	100.6
	1993	M	1	555.0		2,409.5		0.1	171.6
	1991	F	1	683.0		3,478.2		0.1	247.7
5.25	1994	M	10	475.8	19.4	1,596.4	286.7	0.7	1,136.9
		F	1	508.0		2,040.5		0.1	145.3
	1993	M	15	531.4	26.0	2,068.3	319.5	1.1	2,209.5
		F	2	563.0	24.0	2,647.2	73.9	0.1	377.0
	1992	M	4	614.3	12.8	3,066.8	289.4	0.3	873.6
		F	1	601.0		2,781.4		0.1	198.1
6.00	1993	M	1	582.0		2,862.1		0.1	203.8
	1991	F	1	705.0		4,399.9		0.1	313.4

6.50	1991	M	2	733.0	2.8	5,120.9	196.7	0.1	729.4
	1986	F	1	1,015.0		15,827.7		0.1	1,127.2
7.00	1991	F	1	694.0		4,912.7		0.1	349.9
	N/A	F	1	880.0		8,680.5		0.1	618.2
8.00	1990	M	1	769.0		6,351.2		0.1	452.3
	1989	F	1	835.0		7,415.5		0.1	528.1
9.00	1989	F	1	890.0		10,114.0		0.1	720.3
	1988	F	1	990.0		15,703.9		0.1	1,118.4

Table 9. Mean fork length (mm), weight (g), standard deviation (SD) and CPUE (fish per day; weight per day) by year class and sex per panel of striped bass captured in variable-mesh gill net #2 in the Rappahannock River, spring 1998.

Mesh size	Year class	Sex	n	Fork length		Weight		CPUE	
				Mean	SD	Mean	SD	Fish/D	Weight/D
3.00	1996	M	2	292.5	3.5	298.7	10.6	0.1	42.7
	1995	M	1	405.0		816.8		0.1	58.3
	1994	M	2	479.5	30.4	1,462.8	128.5	0.1	209.0
3.75	1995	M	82	394.7	21.5	777.0	114.9	5.9	4,551.0
	1994	M	45	444.5	24.3	1,120.1	200.7	3.2	3,600.3
	1993	M	4	513.8	10.2	1,862.1	141.3	0.3	532.0
	N/A	M	4	420.3	43.4	906.0	304.0	0.3	258.9
4.50	1995	M	3	408.3	6.7	887.3	131.3	0.2	190.1
	1994	M	207	465.6	20.8	1,359.5	197.4	14.8	20,101.2
		F	1	506.0		1,837.2		0.1	131.2
	1993	M	40	518.1	18.6	1,823.4	211.3	2.9	5,209.7
		F	2	548.0	17.0	2,301.9	363.7	0.1	328.8
	1992	F	1	594.0		2,496.0		0.1	178.3
	1991	M	2	702.5	19.1	4,965.3	452.8	0.1	709.3
	N/A	M	8	485.3	26.4	1,592.5	183.3	0.6	910.0
5.25	1994	M	5	475.0	8.6	1,495.0	175.5	0.4	533.9
	1993	M	4	530.0	26.9			0.3	
		F	2	557.0	35.4	2,453.7	382.4	0.1	233.4
	1992	M	1	586.0		2,571.5		0.1	183.7

	1991	M	1	714.0		4,836.0		0.1	345.4
	N/A	M	1	498.0		1,805.7		0.1	129.0
6.00	1994	M	1	429.0		1,025.0		0.1	73.2
	1992	M	1	658.0		3,663.0		0.1	261.6
	1991	F	1	666.0		4,051.6		0.1	289.4
	1986	F	1	973.0		11,256.9		0.1	804.1
	N/A	M	1	668.0		3,835.1		0.1	145.4
		F	1	554.0		2,034.9		0.1	273.9
6.50	1991	F	2	719.0	4.2	5,252.7	142.4	0.1	750.9
	1990	M	1	765.0		5,724.5		0.1	408.9
	1989	F	1	920.0		10,715.6		0.1	765.4
7.00	1991	M	1	680.0		4,804.1		0.1	343.2
	1990	F	1	750.0		5,316.1		0.1	379.7
9.00	1988	F	1	927.0		10,804.1		0.1	771.7
	1987	F	1	946.0		11,097.3		0.1	792.7

N/A- not aged

Table 10. Comparison of catch statistics based on annual catches of striped bass in pound nets in the Rappahannock River during the entire period of sampling each year with catches during a restricted sampling window, 30 March - 3 May, 1993-1998.

Year	Entire Sampling Period						Restricted Sampling Window (30 Mar - 3 May)					
	n		CPUE (kg/day)		Mean age		n		CPUE (kg/day)		Mean age	
	M	F	M	F	M	F	M	F	M	F	M	F
1998	698	119	17.5	21.5	3.7	9.3	278	113	14.9	36.4	4.2	9.4
1997	522	133	19.8	30.2	3.9	9.1	288	118	22.4	49.7	4.0	9.2
1996	455	92	14.2	8.1	3.9	6.3	352	78	14.3	9.4	3.9	7.9
1995	636	190	16.3	15.9	3.2	5.2	280	83	13.5	20.0	3.3	7.2
1994	228	147	17.4	30.9	4.5	7.2	228	147	17.4	30.9	4.5	7.2
1993	374	191	31.4	37.5	4.6	6.9	374	191	31.4	37.5	4.6	6.9
Mean	**486**	**145**	**18.6**	**22.3**	**3.8**	**7.2**	**300**	**122**	**16.5**	**28.8**	**4.1**	**7.7**

Table 11. Comparison of catch statistics based on annual catches of striped bass in variable-mesh nets in the Rappahannock River during the entire period of sampling each year with catches during a restricted sampling window, 30 March - 3 May, 1993-1998.

Year	Entire Sampling Period						Restricted Sampling Window (30 Mar - 3 May)					
	n		CPUE (kg/day)		Mean age		n		CPUE (kg/day)		Mean age	
	M	F	M	F	M	F	M	F	M	F	M	F
1998	574	29	58.6	12.1	3.9	6.9	486	27	81.5	18.5	4.0	7.0
1997	930	24	103.6	14.1	4.0	8.3	806	18	178.1	19.1	4.0	7.9
1996	495	53	54.3	26.7	3.9	7.9	452	46	64.4	30.2	3.9	8.0
1995	422	122	45.6	47.7	3.6	6.6	198	70	45.6	56.8	4.0	7.5
1994	445	115	82.7	54.9	4.7	7.0	416	100	102.7	64.7	4.7	7.1
1993	402	171	66.9	56.5	4.9	6.3	366	160	85.8	74.1	4.9	6.3
Mean	**545**	**86**	**65.2**	**35.5**	**4.0**	**6.8**	**454**	**70**	**88.3**	**45.9**	**4.2**	**6.9**

Table 12. Comparison of catch statistics based on annual catches of striped bass in three pound nets (S441, S462 and S473) in the Rappahannock River, 30 Mar - 3 May, 1993-1998.

Year	CPUE (kg/day)						Mean age					
	S441		S462		S473		S441		S462		S473	
	M	F	M	F	M	F	M	F	M	F	M	F
1998	22.1	23.4	16.0	43.6	23.2	46.6	3.8	9.6	3.8	9.0	3.7	9.0
1997	18.2	34.0			25.8	62.5	3.8	8.7			3.9	9.2
1996	11.4	2.8			25.6	25.6	3.7	6.5			4.0	6.1
1995	5.1	19.1			24.2	21.1	3.2	6.2			3.2	4.7
1994	9.6	10.5			31.3	67.8	5.2	7.1			4.4	7.1
1993	25.4	37.3			52.9	38.0	4.7	7.0			4.5	6.6
Total	**15.5**	**23.7**	**16.0**	**43.6**	**30.7**	**42.2**	**4.0**	**7.2**	**3.8**	**9.0**	**3.7**	**6.9**

Table 13. Comparison of catch statistics based on annual catches of striped bass in two variable-mesh gill nets in the Rappahannock River, 30 Mar - 3 May, 1993-1998.

Year	n				CPUE (kg/day)				Mean age			
	Net 1		Net 2		Net 1		Net 2		Net 1		Net 2	
	M	F	M	F	M	F	M	F	M	F	M	F
1998	157	14	417	15	19.8	6.5	39.7	5.7	3.9	7.3	3.9	7.2
1997	707	9	99	9	88.4	10.2	15.2	3.9	4.0	8.6	3.9	7.0
1996	323	24	129	22	37.7	13.6	16.6	13.0	3.8	7.8	3.9	8.1
1995	115	41	83	29	26.7	26.9	18.9	20.8	3.6	6.6	3.6	6.6
1994	200	48	215	53	42.3	23.8	40.4	31.1	4.9	6.5	4.5	7.3
1993	228	70	138	90	40.2	24.7	26.7	31.8	4.8	6.3	5.0	6.2
Mean	**288**	**34**	**180**	**36**	**38.9**	**17.7**	**26.3**	**17.8**	**4.1**	**6.8**	**4.1**	**6.8**

Table 14. Age, fork length (mm), weight (g) and CPUE (weight per day) by sex per panel of striped bass captured in variable-mesh gill nets in the Rappahannock River, 30 March - 3 May, 1993-1998.

Mesh Size	Sex	Age		N	Mean FL (mm)	Mean Wt. (kg)	CPUE (kg/day)
		Range	Mean				
3.00	**M**	2 - 6	3.0	293	383.5	0.9	4.9
	F	2 - 6	2.7	14	345.3	0.8	0.2
3.75	**M**	2 - 8	3.4	1066	418.9	1.0	20.1
	F	2 - 10	4.6	25	521.3	2.5	1.0
4.50	**M**	2 - 9	4.2	1059	475.8	1.5	30.0
	F	3 - 10	5.3	32	582.9	2.9	1.7
5.25	**M**	3 - 11	5.0	600	555.6	2.3	26.0
	F	4 - 12	5.7	88	624.7	3.7	6.2
6.00	**M**	4 - 8	5.7	127	611.7	3.3	7.5
	F	5 - 12	7.0	100	713.5	5.4	9.3
6.50	**M**	3 - 9	6.0	69	644.0	3.8	4.8
	F	5 - 12	6.9	93	708.4	5.3	10.0
7.00	**M**	3 - 9	6.6	41	671.5	4.5	3.5
	F	5 - 13	7.6	70	755.7	6.6	8.3
8.00	**M**	4 - 9	6.3	9	642.3	4.1	0.7
	F	5 - 11	8.8	52	837.3	8.5	9.4
9.00	**M**	3 - 6	5.0	7	553.2	2.7	0.3
	F	5 - 11	9.3	28	877.1	9.5	3.7
10.00	**M**	6 - 10	8.0	2	771.5	6.1	0.2
	F	6 - 11	9.5	6	879.7	10.2	1.2

Table 15. Catch rates (fish/day) of year classes of striped bass (sexes combined) sampled from pound nets in the Rappahannock River, 30 March - 3 May, 1993-1998. Maximum catch rate for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	CPUE (fish/day)					
	1993	1994	1995	1996	1997	1998
1996						(2) **0.2**
1995					(2) 0.6	(3) **2.1**
1994			(1) 0.1	(2) 0.5	(3) 3.9	(4) **6.3**
1993			(2) 3.1	(3) 3.9	(4) **8.1**	(5) 1.5
1992	(1) 0.1	(2) 1.4	(3) **4.8**	(4) 2.9	(5) 1.3	(6) 0.1
1991	(2) 0.7	(3) 0.5	(4) 1.0	(5) **1.6**	(6) 0.1	(7) 0.5
1990	(3) 1.0	(4) 1.3	(5) **2.2**	(6) 1.3	(7) 0.7	(8) 0.7
1989	(4) 3.6	(5) **4.6**	(6) 0.7	(7) 0.9	(8) 0.8	(9) 0.8
1988	(5) **9.5**	(6) 2.2	(7) 0.6	(8) 0.4	(9) 1.5	(10) 0.9
1987	(6) **3.7**	(7) 1.1	(8) 0.7	(9) 0.4	(10) 1.0	(11) 0.9
1986	(7) 0.7	(8) 0.6	(9) 0.4	(10) 0.9	(11) **1.0**	(12) 0.2
1985	(8) 0.4	(9) **0.5**	(10) 0.1	(11) 0.0	(12) 0.4	(13) 0.1
1984	(9) **0.6**	(10) 0.3	(11) 0.3	(12) 0.0	(13) 0.4	(14) < 0.1
1983	(10) **0.5**	(11) 0.3	(12) 0.1	(13) < 0.1	(14) 0.2	
1982	(11) **0.3**	(12) 0.2				
1981	(12) **0.3**	(13) <0.1				
1980	(13) **0.2**	(14) <0.1				
1979		(15) <0.1				

Not aged	0.4	0.6	0.6	0.3	0.5	0.4
Total	**21.8**	**13.9**	**14.5**	**12.3**	**20.3**	**14.9**

Table 16. Catch rates (fish/day) of year classes of striped bass (sexes combined) sampled from experimental-mesh nets in the Rappahannock River, 30 March - 3 May, 1993-1998. Maximum catch rate (>0.1) for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	CPUE (fish/day)					
	1993	1994	1995	1996	1997	1998
1996						(2) 0.1
1995					(2) 0.8	(3) **11.7**
1994				(2) 1.9	(3) 29.5	(4) **32.8**
1993			(2) 4.5	(3) 20.0	(4) **83.0**	(5) 7.0
1992		(2) 2.8	(3) 7.0	(4) 11.4	(5) **14.3**	(6) 0.8
1991	(2) 0.5	(3) 2.6	(4) 1.9	(5) **5.7**	(6) 2.8	(7) 1.3
1990	(3) 1.5	(4) **8.2**	(5) 7.8	(6) 3.5	(7) 2.2	(8) 0.3
1989	(4) 8.6	(5) **27.6**	(6) 4.5	(7) 2.5	(8) 0.7	(9) 0.3
1988	(5) **25.4**	(6) 8.2	(7) 2.9	(8) 1.5	(9) 1.2	(10) 0.3
1987	(6) **10.4**	(7) 2.1	(8) 1.8	(9) 1.6	(10) 0.5	(11) 0.1
1986	(7) **2.6**	(8) 0.4	(9) 1.4	(10) 0.3		(12) 0.2
1985	(8) 0.4	(9) **1.7**	(10) 0.8	(11) 0.2		
1984	(9) 0.4	(10) **0.7**	(11) 0.3			
1983	(10) **1.3**	(11) 0.6	(12) 0.1			
1982	(11) **0.4**	(12) 0.2				
1981						
1980	(13) **0.2**					
1979						
Not aged	1.1	0.8	1.0	1.2	2.5	2.0

Total	52.8	55.8	33.8	49.8	137.5	57.0

Table 17. Catch rates (fish/day) of year classes of male striped bass sampled from pound nets in the Rappahannock River, 30 March - 3 May, 1993-1998. Maximum catch rate (>0.1) for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	CPUE (fish/day)					
	1993	1994	1995	1996	1997	1998
1996						(2) **0.2**
1995					(2) 0.6	(3) **2.1**
1994			(1) < 0.1	(2) 0.5	(3) 3.8	(4) **6.2**
1993			(2) 2.9	(3) 3.8	(4) **7.5**	(5) 1.4
1992	(1) 0.2	(2) 1.2	(3) **4.9**	(4) 2.7	(5) 1.2	(6) 0.0
1991	(2) 0.5	(3) 0.5	(4) 0.9	(5) **1.3**	(6) 0.6	(7) 0.3
1990	(3) 0.9	(4) 1.3	(5) **2.0**	(6) 0.9	(7) 0.4	(8) 0.1
1989	(4) **3.5**	(5) **3.5**	(6) <0.1	(7) 0.4	(8) 0.6	(9) <0.1
1988	(5) **7.5**	(6) 1.1	(7) 0.1	(8) <0.1	(9) 0.2	
1987	(6) **1.2**	(7) 0.2	(8) 0.0	(9) <0.1		
1986	(7) 0.2	(8) 0.1	(9) <0.1			
1985	(8) <0.1	(9) <0.1				
1984	(9) <0.1					
1983						
1982		(12) <0.1				
1981						
1980						
1979						

Not aged	0.3	0.4	0.4	0.2	0.3	0.3
Total	**14.4**	**8.4**	**11.2**	**10.0**	**14.4**	**10.7**

Table 18. Catch rates (fish/day) of year classes of male striped bass sampled from experimental-mesh nets in the Rappahannock River, 30 March - 3 May, 1993-1998. Maximum catch rate (>0.1) for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	CPUE (fish/day)											
	1993		1994		1995		1996		1997		1998	
1996											(2)	0.1
1995									(2)	0.8	(3)	**11.7**
1994							(2)	1.9	(3)	29.5	(4)	**32.6**
1993					(2)	4.5	(3)	20.0	(4)	**82.5**	(5)	6.4
1992			(2)	2.8	(3)	6.8	(4)	11.3	(5)	**14.0**	(6)	0.6
1991	(2)	0.5	(3)	2.6	(4)	1.8	(5)	**5.6**	(6)	2.5	(7)	0.7
1990	(3)	1.5	(4)	**8.2**	(5)	7.0	(6)	3.2	(7)	1.8	(8)	0.2
1989	(4)	8.2	(5)	**25.3**	(6)	2.6	(7)	1.4	(8)	0.5		
1988	(5)	**20.3**	(6)	4.9	(7)	1.1	(8)	0.5	(9)	0.2		
1987	(6)	**4.2**	(7)	0.3	(8)	0.1	(9)	0.1				
1986	(7)	**0.9**	(8)	0.1								
1985			(9)	**0.3**								
1984	(9)	0.1	(10)	0.1								
1983												
1982	(11)	0.1										
1981												
1980												
1979												
Not aged		0.8		1.6		0.9		1.2		2.5		1.8

Total	**36.6**	**46.2**	**24.8**	**45.2**	**134.3**	**54.0**

Table 19. Catch rates (fish/day) of year classes of female striped bass sampled from pound nets in the Rappahannock River, 30 March - 3 May, 1993-1998. Maximum catch rate (>0.1) for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	CPUE (fish/day)					
	1993	1994	1995	1996	1997	1998
1996						
1995					(2) <0.1	
1994					(3) 0.1	(4) 0.1
1993			(2) 0.2	(3) 0.1	(4) **0.6**	(5) 0.1
1992		(2) **0.2**	(3) 0.1	(4) **0.2**	(5) 0.1	(6) <0.1
1991	(2) <0.1		(4) <0.1	(5) **0.3**		(7) 0.2
1990	(3) <0.1	(4) <0.1	(5) 0.2	(6) 0.3	(7) 0.4	(8) **0.6**
1989	(4) 0.1	(5) **1.1**	(6) 0.6	(7) 0.5	(8) 0.3	(9) 0.7
1988	(5) **2.0**	(6) 1.1	(7) 0.5	(8) 0.3	(9) 1.3	(10) 0.9
1987	(6) **2.4**	(7) 0.9	(8) 0.7	(9) 0.3	(10) 1.0	(11) 0.9
1986	(7) 0.5	(8) 0.5	(9) 0.4	(10) <0.1	(11) 1.0	(12) 0.2
1985	(8) 0.4	(9) **0.5**	(10) <0.1		(12) 0.4	(13) 0.1
1984	(9) **0.5**	(10) 0.3	(11) 0.3		(13) 0.4	(14) <0.1
1983	(10) **0.5**	(11) 0.3	(12) <0.1	(13) <0.1	(14) 0.2	
1982	(11) **0.3**	(12) 0.1				
1981	(12) **0.3**	(13) <0.1				
1980	(13) **0.2**	(14) <0.1				
1979		(15) <0.1				

Not aged	0.1	0.1	0.2	0.1	0.3	0.1
Total	**7.3**	**5.4**	**3.3**	**2.2**	**5.9**	**4.2**

Table 20. Catch rates (fish/day) of year classes of female striped bass sampled from experimental gill nets in the Rappahannock River, 30 March - 3 May, 1993-1998. Maximum catch rate (>0.1) for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	CPUE (fish/day)					
	1993	1994	1995	1996	1997	1998
1996						
1995						
1994						(4) **0.2**
1993					(4) 0.3	(5) **0.6**
1992			(3) 0.1	(4) 0.1	(5) **0.3**	(6) 0.2
1991			(4) 0.1	(5) 0.1	(6) 0.3	(7) **0.7**
1990			(5) **0.6**	(6) 0.3	(7) 0.3	(8) 0.1
1989	(4) 0.3	(5) **2.2**	(6) 1.9	(7) 1.1	(8) 0.2	(9) 0.3
1988	(5) **5.1**	(6) 3.3	(7) 1.8	(8) 1.0	(9) 1.0	(10) 0.3
1987	(6) **6.1**	(7) 1.8	(8) 1.6	(9) 1.5	(10) 0.5	(11) 0.1
1986	(7) **1.7**	(8) 0.3	(9) 1.4	(10) 0.3		(12) 0.2
1985	(8) 0.4	(9) **1.3**	(10) 0.8	(11) 0.2		
1984	(9) 0.3	(10) **0.6**	(11) 0.3			
1983	(10) **1.3**	(11) 0.6	(12) 0.1			
1982	(11) **0.3**	(12) 0.2				
1981						
1980	(13) **0.2**					
1979						

Not aged	0.3	0.8	0.1	0.0	0.0	0.2
Total	**16.0**	**11.1**	**8.8**	**4.6**	**3.0**	**3.0**

Table 21. Estimated annual and geometric mean survival (S) rates for year classes of striped bass (both sexes combined) sampled from pound nets in the Rappahannock River, 30 March - 3 May, 1993-1998.

Year Class	93-94 S	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1996						------
1995					------	------
1994			------	------	------	------
1993			------	------	0.18	0.18
1992	------	------	0.60	0.44	0.03	0.20
1991	------	------	------	0.56	0.56	0.56
1990	------	------	0.56	0.75	0.75	0.68
1989	------	0.44	0.44	0.90	0.97	0.64
1988	0.23	0.88	0.88	0.88	0.59	0.62
1987	0.31	0.96	0.96	0.96	0.89	0.75
1986	------	------	------	------	0.22	0.22
1985	------	0.88	0.88	0.88	0.42	0.73
1984	0.88	0.88	0.88	0.88	0.21	0.66
1983	0.72	0.84	0.84	0.84	0.00	0.61
1982	0.60	0.00				0.27
1981	0.28	0.00				0.13
1980	0.24	0.00				0.11

Table 22. Estimated annual and geometric mean survival (S) rates for year classes of striped bass (both sexes combined) sampled from gill nets in the Rappahannock River, 30 March - 3 May, 1993-1998.

Year Class	93-94 S	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1996						------
1995					------	------
1994				------	------	------
1993			------	------	0.08	0.08
1992		------	------	------	0.05	0.05
1991	------	------	------	0.50	0.47	0.48
1990	------	0.94	0.45	0.62	0.15	0.45
1989	------	0.16	0.56	0.27	0.50	0.33
1988	0.32	0.35	0.52	0.78	0.29	0.42
1987	0.20	0.83	0.91	0.31	0.22	0.40
1986	0.73	0.73	0.22	0.86	0.86	0.61
1985	------	0.45	0.27	0.00		0.23
1984	------	0.37	0.00			0.17
1983	0.43	0.23	0.00			0.21
1982	0.56	0.00				0.25

Table 23. Estimated annual and geometric mean survival (S) rates for year classes of male striped bass sampled from pound nets in the Rappahannock River, 30 March - 3 May, 1993-1998.

Year Class	93-94 S	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1996						------
1995					------	------
1994			------	------	------	------
1993			------	------	0.18	0.18
1992	------	------	0.57	0.44	0.00	0.32
1991	------	------	------	0.47	0.47	0.47
1990	------	------	0.47	0.37	0.32	0.38
1989	------	0.54	0.54	0.54	0.07	0.32
1988	0.15	0.57	0.57	0.57	0.00	0.35
1987	0.18	0.62	0.62	0.00		0.33
1986	0.72	0.22	0.00			0.28

Table 24. Estimated annual and geometric mean survival (S) rates for year classes of male striped bass sampled from gill nets in the Rappahannock River, 30 March - 3 May, 1993-1998.

Year Class	93-94 S	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1996						------
1995					------	------
1994				------	------	------
1993			------	------	0.08	0.08
1992		------	------	------	0.04	0.04
1991	------	------	------	0.45	0.27	0.35
1990	------	0.85	0.46	0.57	0.03	0.28
1989	------	0.10	0.57	0.36	0.00	0.24
1988	0.24	0.23	0.44	0.33	0.00	0.24
1987	0.08	0.38	0.80	0.00		0.28
1986	0.12	0.00				0.06
1985	------	0.00				
1984	------	0.00				

Table 25. Estimated annual and geometric mean survival (S) rates for year classes of female striped bass sampled from pound nets in the Rappahannock River, 30 March - 3 May, 1993-1998.

Year Class	93-94 S	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1996						
1995					0.00	------
1994					------	------
1993			------	------	0.19	0.19
1992		0.95	0.95	0.50	0.04	0.36
1991	------	------	------	0.88	0.88	0.88
1990	------	------	------	------	------	------
1989	------	0.91	0.91	0.91	0.91	0.91
1988	0.90	0.90	0.90	0.90	0.68	0.85
1987	0.80	0.80	0.80	0.80	0.89	0.82
1986	------	------	------	------	0.22	0.22
1985	------	0.90	0.90	0.90	0.43	0.75
1984	0.92	0.92	0.92	0.92	0.21	0.68
1983	0.72	0.84	0.84	0.84	0.00	0.61
1982	0.48	0.00				0.22
1981	0.28	0.00				0.13
1980	0.24	0.00				0.11

Table 26. Estimated annual and geometric mean survival (S) rates for year classes of female striped bass sampled from gill nets in the Rappahannock River, 30 March - 3 May, 1993-1998.

Year Class	93-94 S	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1996						
1995						
1994						------
1993					------	------
1992			------	------	0.67	0.67
1991			------	------	------	------
1990			0.73	0.73	0.33	0.56
1989	------	0.84	0.53	0.55	0.55	0.61
1988	0.64	0.53	0.76	0.76	0.33	0.58
1987	0.29	0.91	0.92	0.33	0.22	0.34
1986	0.92	0.92	0.22	0.86	0.86	0.67
1985	------	0.56	0.27	0.00		0.26
1984	------	0.45	0.00			0.20
1983	0.46	0.23	0.00			0.22
1982	0.74	0.00				0.32

Table 27. Values of the spawning stock biomass index (SSBI) for male and female striped bass by gear in the Rappahannock River, 30 March - 3 May, 1993-1998.

Year	Pound nets					Gill nets				
	N		SSBI (kg/day)			N		SSBI (kg/day)		
	M	F	M	F	M+F	M	F	M	F	M+F
1998	273	113	14.8	36.4	51.2	485	27	81.5	18.5	100.0
1997	277	115	22.2	49.6	71.7	801	18	177.8	19.1	197.0
1996	334	73	14.1	9.3	23.4	433	46	63.7	30.2	93.9
1995	207	76	12.4	19.8	32.2	162	69	43.9	56.7	100.6
1994	195	141	17.1	30.9	48.0	391	100	101.6	64.7	166.3
1993	357	188	31.2	37.5	68.7	361	160	85.6	74.1	159.6
Mean	**274**	**118**	**18.2**	**28.7**	**47.0**	**439**	**70**	**87.6**	**45.9**	**133.5**

Table 28. Mean fork length (mm), weight (g), standard deviations (SD) and CPUE (fish and weight per net per day) of striped bass from variable-mesh gill nets (combined data) in the James River, spring 1998.

Year Class	Sex	n	Fork Length		Weight		CPUE	
			Mean	SD	Mean	SD	F/day	W/day
1995	male	17	382.3	27.2	806.8	161.7	1.1	914.4
1994	male	69	459.4	27.6	1,449.1	312.7	4.6	6,666.9
	female	3	470.0	32.7	1,656.9	411.0	0.2	331.4
1993	male	41	537.6	24.1	2,367.9	386.2	2.7	6,472.3
	female	17	553.0	24.0	2,497.0	360.9	1.1	2,829.9
1992	male	20	618.3	32.3	3,530.5	595.2	1.3	4,707.3
	female	13	651.7	41.2	4,028.5	774.7	0.9	3,491.4
1991	male	10	700.5	25.8	4,877.1	597.0	0.7	3,251.4
	female	7	706.0	24.8	5,348.4	532.8	0.5	2,495.9
1990	male	2	739.0	22.6	5,512.7	384.5	0.1	735.0
	female	5	770.0	22.0	6,538.9	724.5	0.3	2,179.6
1989	female	10	852.8	25.7	8,744.5	1,022.8	0.7	5,829.7
1988	male	2	907.5	10.6	8,797.5	480.1	0.1	1,173.0
	female	7	903.7	26.2	10,648.1	1,189.0	0.5	4,969.1
1987	female	6	939.5	31.3	10,952.8	777.9	0.4	4,381.1
1986	female	1	1,009.0		13,630.4		0.1	908.7
1985	female	1	1,050.0		17,493.5		0.1	1,166.2
N/A	male	3	644.0	145.6	4,056.4	2,053.1	0.2	811.3
	female	2	846.0	196.6	8,119.9	3,889.4	0.1	1,082.7

N/A- not aged

Table 29. Catches of striped bass in variable-mesh gill nets in the James River, by sex, year class and date in spring 1998.

Date	n	Year class							
		1994 - 1995		1990 - 1993		1985 - 1989		Not aged	
		M	F	M	F	M	F	M	F
9 March	16	8	0	4	3	0	1	0	0
12 March	3	1	0	1	1	0	0	0	0
16 March	2	0	0	2	0	0	0	0	0
19 March	8	3	0	4	1	0	0	0	0
23 March	5	1	0	1	1	0	0	2	0
26 March	3	1	0	1	0	1	0	0	0
30 March	8	1	2	0	3	0	2	0	0
2 April	40	14	0	14	6	0	6	0	0
6 April	6	1	0	0	2	0	2	0	1
9 April	64	30	0	24	6	0	3	1	0
13 April	27	12	0	9	2	0	4	0	0
16 April	9	2	0	2	3	0	1	0	1
20 April	16	2	1	3	7	0	3	0	0
23 April	12	6	0	1	3	0	2	0	0
30 April	17	4	0	7	4	1	1	0	0
Total	**236**	**86**	**3**	**73**	**42**	**2**	**25**	**3**	**2**

Table 30. Net-specific summary of catch rates (fish per day; weight per day) and ages of striped bass in variable-mesh gill nets sampled from the James River, spring 1998.

Date	Net ID	n	Catch Rate (no./day)		Catch Rate (g/day)		Mean age	
			M	F	M	F	M	F
9 March	1	10	7.0	3.0	10,494.5	16,776.9	3.7	7.3
	2	6	5.0	1.0	11,669.3	2,092.0	4.6	5.0
12 March	1	2	2.0	0.0	3,674.5	0.0	4.5	----
	2	1	0.0	1.0	0.0	2,863.1	----	6.0
16 March	1	2	2.0	0.0	4,442.9	0.0	5.0	----
	2	0	0.0	0.0	0.0	0.0	----	----
19 March	1	1	1.0	0.0	3,422.4	0.0	6.0	----
	2	7	6.0	1.0	13,092.8	2,699.4	4.5	5.0
23 March	1	2	2.0	0.0	6,978.3	0.0	----	----
	2	3	2.0	1.0	4,582.6	2,221.6	5.0	5.0
26 March	1	2	2.0	0.0	6,731.4	0.0	5.5	----
	2	1	1.0	0.0	9,137.0	0.0	10.0	----
30 March	1	2	0.0	2.0	0.0	11,153.3	----	7.0
	2	6	1.0	5.0	1,743.1	26,899.3	4.0	6.6
2 April	1	27	21.0	6.0	49,690.8	42,814.9	4.7	7.5
	2	13	7.0	6.0	17,494.4	46,110.0	4.9	8.3
6 April	1	5	1.0	4.0	1,104.9	28,632.2	4.0	7.3
	2	1	0.0	1.0	0.0	11,353.3	----	10.0
9 April	1	51	47.0	4.0	89,120.3	30,818.7	4.5	8.5
	2	13	8.0	5.0	20,768.4	26,782.6	5.0	6.6

13 April	1	18	14.0	4.0	34,749.8	30,988.5	4.8	8.8
	2	9	7.0	2.0	11,112.6	17,347.8	4.1	9.0
16 April	1	8	3.0	5.0	10,919.0	26,032.2	6.0	7.0
	2	1	1.0	0.0	953.3	0.0	4.0	----
20 April	1	10	3.0	7.0	7,362.1	43,114.7	5.0	7.0
	2	6	2.0	4.0	5,568.2	20,891.6	5.5	6.8
23 April	1	10	6.0	4.0	6,617.8	24,041.2	3.7	8.0
	2	2	1.0	1.0	2,158.2	2,937.0	5.0	6.0
30 April	1	11	8.0	3.0	16,193.2	13,824.3	4.9	6.7
	2	6	4.0	2.0	21,178.0	14,590.5	7.5	8.0
Totals	1	161	7.9	2.8	16,766.8	17,879.8	4.6	7.5
	2	75	3.0	2.0	7,963.9	11,785.9	5.1	7.2
Season		236	10.9	4.8	24,730.7	29,665.7	4.7	7.4

Table 31. Mean fork length(mm), weight (g), standard deviation (SD) and catch rate (number of fish; weight per day) by year class and sex per panel of striped bass captured in variable-mesh gill net #1 in the James River, spring 1998.

Mesh size	Year class	Sex	n	Fork length		Weight		Catch Rate	
				Mean	SD	Mean	SD	Fish/D	Weight/D
3.00	1994	M	2	433.0	18.4	1107.2	306.2	0.1	147.6
3.75	1995	M	12	387.3	24.5	812.6	146.8	0.8	650.1
	1994	M	12	448.4	22.9	1321.2	246.4	0.8	1057.0
	1993	M	7	535.3	24.9	2370.8	502.3	0.5	1106.4
		F	1	587.0		3097.3		0.1	206.5
	1992	M	1	610.0		2999.8		0.1	200.0
	N/A	F	1	985.0		10870.1		0.1	724.7
4.50	1995	M	1	416.0		1092.3		0.1	72.8
	1994	M	31	457.1	26.2	1406.0	278.5	2.1	2905.7
		F	1	433.0		1183.6		0.1	78.9
	1993	M	12	526.3	27.0	2112.4	369.9	0.8	1698.9
		F	2	557.0	26.9	2434.8	367.1	0.1	324.6
	1992	M	3	615.7	29.5	3224.6	461.3	0.2	644.9
		F	1	694.0		3808.5		0.1	253.9
	1991	M	1	707.0		4028.4		0.1	268.6
	1990	F	1	787.0		6872.4		0.1	458.2
5.25	1994	M	3	496.7	6.1	1912.5	178.9	0.2	382.5
		F	1	495.0		1924.1		0.1	128.3
	1993	M	3	558.3	11.0	2721.1	184.7	0.2	544.2
		F	2	531.5	2.1	2234.8	131.5	0.1	298.0
	1992	M	1	577.0		3140.9		0.1	209.4

		F	1	629.0		3933.6		0.1	262.2
	N/A	M	1	482.0		1686.4		0.1	112.4
6.00	1994	M	3	496.7	6.1	1912.5	178.9	0.2	382.5
	1993	M	4	524.3	17.0	2317.4	196.4	0.3	618.0
		F	2	538.5	7.8	2515.8	196.4	0.1	335.4
6.00	1992	M	2	589.0	18.4	2928.1	334.0	0.1	390.4
		F	1	660.0		3985.8		0.1	265.7
	1990	F	1	754.0		5754.5		0.1	383.6
	1989	F	1	811.0		9942.0		0.1	662.8
	1986	F	1	1009.0		13630.4		0.1	908.7
6.50	1993	M	2	554.5	30.4	2798.9	253.2	0.1	373.2
		F	2	563.5	10.6	2879.6	15.9	0.1	384.0
	1992	M	5	619.8	42.7	3849.2	561.9	0.3	1283.1
		F	1	632.0		3859.6		0.1	257.3
	1991	M	4	675.3	15.9	4636.0	437.9	0.3	1236.3
		F	1	665.0		4553.1		0.1	303.5
	1990	F	1	757.0		6261.5		0.1	417.4
	1988	F	1	885.0		9600.2		0.1	640.0
7.00	1994	M	1	490.0		1545.0		0.1	103.0
	1993	M	2	544.0	25.5	2280.0	207.2	0.1	304.0
	1992	M	1	677.0		5144.1		0.1	342.9
		F	1	682.0		4703.8		0.1	313.6
	1991	M	3	725.0	17.1	5485.1	463.8	0.2	1097.0
		F	4	708.3	21.8	5279.0	327.5	0.3	1407.7
	1989	F	1	820.0		7119.0		0.1	474.6
	1987	F	1	935.0		10831.2		0.1	722.1

	N/A	M	2	725.0	55.2	5241.4	71.4	0.1	698.9
		F	1	707.0		5369.6		0.1	358.0
8.00	1988	F	1	870.0		9229.2		0.1	615.3
	1987	F	1	951.0		9900.6		0.1	660.0
9.00	1993	F	1	536.0		2177.9		0.1	145.2
	1989	F	3	869.3	16.0	8963.9	384.4	0.2	1792.8
	1988	F	2	897.5	10.6	11284.7	1977.9	0.1	1504.6
	1987	F	2	968.0	32.5	10694.3	582.3	0.1	1425.9
10.00	1985	F	1	1050.0		17493.5		0.1	1166.2

N/A- not aged

Table 32. Mean fork length(mm), weight (g), standard deviation (SD) and catch rate (number of fish; weight per day) by year class and sex per panel of striped bass captured in gill net # 2 in the James River, spring 1998.

Mesh size	Year class	Sex	n	Fork length		Weight		Catch Rate	
				Mean	SD	Mean	SD	Fish/D	Weight/D
3.75	1995	M	4	359.0	23.3	717.8	150.5	0.3	191.4
	1994	M	9	453.9	25.6	1345.7	287.5	0.6	807.4
	1993	M	1	552.0		2609.6		0.1	174.0
		F	1	515.0		1804.4		0.1	120.3
	1992	M	2	641.0	24.0	3322.0	66.0	0.1	442.9
4.50	1994	M	3	474.0	40.6	1683.0	349.6	0.2	336.6
		F	1	482.0		1863.0		0.1	124.2
5.25	1994	M	5	476.8	27.7	1793.3	318.9	0.3	597.8
	1993	M	5	540.4	20.9	2379.7	325.3	0.3	793.2
		F	4	560.8	25.5	2431.8	322.0	0.3	648.5
	1992	M	1	621.0		3649.8		0.1	243.3
		F	1	600.0		2863.1		0.1	190.9
6.00	1993	M	5	551.6	19.8	2607.7	288.6	0.3	869.2
		F	2	569.5	33.2	2756.3	255.0	0.1	367.5
	1992	M	1	603.0		3250.2		0.1	216.7
		F	2	626.0	45.3	3374.7	484.9	0.1	450.0
	1991	F	1	727.0		6162.4		0.1	410.8
	1990	M	1	755.0		5784.0		0.1	385.6
	1989	F	2	854.5	7.8	8324.6	931.6	0.1	1110.0
	1988	M	1	900.0		8458.0		0.1	563.9
		F	1	900.0		11018.4		0.1	734.6

6.50	1992	M	3	624.0	27.5	3668.2	263.3	0.2	733.6
		F	3	645.3	59.2	4249.3	1144.5	0.2	849.9
6.50	1991	M	2	711.0	7.1	4871.6	375.0	0.1	649.6
		F	1	717.0		5607.1		0.1	373.8
	1990	M	1	723.0		5240.8		0.1	349.4
	1989	F	2	847.5	24.8	8580.5	1656.9	0.1	1144.1
	1988	F	1	944.0		11353.3		0.1	756.9
	1987	F	1	905.0		11826.9		0.1	788.5
7.00	1992	F	2	693.5	7.8	4859.4		0.1	647.9
	1990	F	1	752.0		6185.2		0.1	412.4
9.00	1990	F	1	800.0		7620.9		0.1	508.1
	1989	F	1	885.0		9681.9		0.1	645.5
	1988	M	1	915.0		9137.0		0.1	609.1
		F	1	932.0		10766.1		0.1	717.7
	1987	F	1	910.0		11769.6		0.1	784.6

N/A- not aged

Table 33. Comparison of the catch statistics based on annual catches of striped bass in fyke nets in the James River during the entire sampling period each year with catches during a restricted sampling window, 30 March - 3 May, 1994-1997.

Year	Total season						Restricted season (30 Mar - 3 May)					
	n		Catch Rate (kg/day)		Mean age		n		Catch Rate (kg/day)		Mean age	
	M	F	M	F	M	F	M	F	M	F	M	F
1997	173	42	4.2	2.6	4.1	5.9	144	39	6.2	4.3	4.1	6.0
1996	486	91	15.6	8.3	4.2	6.6	403	82	18.7	10.8	4.3	6.9
1995	827	187	25.4	12.8	3.8	5.4	668	150	38.6	21.0	3.9	5.8
1994	165	40	28.2	17.0	4.1	6.2	144	35	48.3	29.7	4.2	6.3
Mean	**413**	**90**	**15.5**	**8.6**	**4.0**	**5.9**	**340**	**77**	**21.7**	**12.5**	**4.1**	**6.2**

Note: The 1994 sample consisted of only one fyke net.
Totals were adjusted as follows:

Males	1.891 x FN # 1
Females	1.678 x FN # 1

Table 34. Comparison of the catch statistics based on annual catches of striped bass in variable-mesh gill nets in the James River during the entire period of sampling each year with catches during a restricted sampling window, 30 March - 3 May, 1994-1998.

Year	Total season						Restricted season (30 Mar - 3 May)					
	n		Catch Rate (kg/day)		Mean age		n		Catch Rate (kg/day)		Mean age	
	M	F	M	F	M	F	M	F	M	F	M	F
1998	164	72	24.7	34.2	4.7	7.4	134	65	33.0	46.5	4.7	7.5
1997	108	65	15.9	29.2	5.0	7.9	100	60	23.9	44.6	4.9	7.9
1996	138	85	20.1	34.8	5.1	7.4	109	74	23.8	43.5	4.8	7.5
1995	316	236	42.4	79.6	4.4	6.7	216	203	52.4	125.3	4.4	6.8
1994	155	81	31.4	41.8	4.4	6.4	115	61	44.9	62.9	4.4	6.5
Mean	**176**	**108**	**26.9**	**44.7**	**4.6**	**7.0**	**135**	**93**	**34.4**	**64.2**	**4.6**	**7.1**

Note: The 1994 data consisted of one gill net (GN # 1).
Totals were adjusted as follows:

Males	1.806 x GN # 1
Females	1.928 x GN # 1

Table 35. Comparison of the catch statistics based on annual catches of striped bass in the two fyke nets in the James River, 30 March - 3 May, 1995-1997.

Year	n				Catch Rate (kg/day)				Mean age			
	T5512		T5513		T5512		T5513		T5512		T5513	
	M	F	M	F	M	F	M	F	M	F	M	F
1997	71	10	70	29	2.8	1.6	3.4	2.7	4.3	7.5	3.9	5.5
1996	388	38	7	43	11.4	5.7	7.2	5.1	4.3	7.2	6.1	6.6
1995	558	79	75	68	22.8	11.4	15.8	9.5	3.7	5.9	5.2	5.8
Mean	**339**	**42**	**51**	**47**	**11.9**	**6.0**	**8.5**	**5.6**	**4.0**	**6.4**	**4.6**	**6.0**

Table 36. Comparison of the catch statistics based on annual catches of striped bass in two variable-mesh gill nets in the James River, 30 march - 3 May, 1995-1998.

Year	n				Catch Rate (kg/day)				Mean age			
	Net 1		Net 2		Net 1		Net 2		Net 1		Net 2	
	M	F	M	F	M	F	M	F	M	F	M	F
1998	103	39	31	26	24.0	27.9	9.0	18.6	4.6	7.5	5.1	7.4
1997	60	26	40	34	14.8	19.3	9.1	25.3	4.9	7.9	4.9	7.8
1996	60	47	49	27	12.4	26.9	11.4	16.6	4.7	7.3	4.9	7.6
1995	96	106	120	97	24.4	62.1	28.0	63.2	4.5	6.0	4.3	7.3
Mean	**80**	**55**	**60**	**46**	**20.2**	**43.3**	**19.0**	**43.1**	**4.6**	**6.8**	**4.6**	**7.5**

Table 37. Age, fork length (mm), weight (g) and catch rate (kg/net day) by sex per panel of striped bass captured in variable-mesh gill nets in the James River, 30 March - 3 May, 1994-1998.

Mesh Size	Sex	Age		N	Mean FL (mm)	Mean Wt. (kg)	Catch Rate (kg/day)
		Range	Mean				
3.00	**M**	2 - 7	3.5	16	433.6	1.1	0.4
	F	4 - 8	6.0	2	620.5	4.4	0.2
3.75	**M**	2 - 7	3.3	193	450.4	1.4	6.2
	F	3 - 5	4.5	12	569.2	3.0	0.9
4.50	**M**	3 - 7	4.2	227	486.9	2.0	10.9
	F	3 - 10	5.2	60	545.3	3.1	4.4
5.25	**M**	2 - 8	4.7	170	521.2	2.1	8.9
	F	4 - 8	6.0	67	585.2	3.0	4.8
6.00	**M**	3 - 10	5.7	79	592.1	3.2	6.0
	F	4 - 12	6.7	89	685.2	5.1	10.8
6.50	**M**	4 - 8	5.9	82	619.7	3.6	10.0
	F	4 - 12	7.0	100	709.1	5.7	13.5
7.00	**M**	3 - 11	6.1	31	644.2	4.1	3.1
	F	6 - 11	7.7	82	779.8	6.6	12.8
8.00	**M**	5 - 9	6.5	8	662.4	4.7	0.9
	F	6 - 13	8.9	32	830.9	8.6	6.6
9.00	**M**	4 - 10	6.5	4	671.8	4.5	0.4
	F	5 - 13	10.1	46	896.6	10.4	11.4
10.00	**M**						
	F	6 - 13	10.4	10	922.7	12.3	2.9

Table 38. Catch rates (fish/day) of year classes of striped bass (sexes combined) sampled from variable-mesh gill nets in the James River, 30 March - 3 May, 1994-1998. Maximum annual catch rate for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	Catch Rate (fish/day)									
	1994		1995		1996		1997		1998	
1995									(3)	**1.2**
1994					(2)	0.1	(3)	1.6	(4)	**7.1**
1993			(2)	0.7	(3)	1.6	(4)	4.4	(5)	**5.2**
1992			(3)	**4.3**	(4)	2.9	(5)	3.3	(6)	3.0
1991	(3)	2.4	(4)	**8.9**	(5)	4.5	(6)	2.0	(7)	1.7
1990	(4)	**12.4**	(5)	11.1	(6)	3.1	(7)	2.0	(8)	0.8
1989	(5)	**12.2**	(6)	9.8	(7)	2.7	(8)	0.9	(9)	1.1
1988	(6)	**3.6**	(7)	2.7	(8)	1.0	(9)	1.4	(10)	0.8
1987	(7)	0.8	(8)	**2.7**	(9)	1.0	(10)	1.1	(11)	0.7
1986	(8)	0.8	(9)	**1.9**	(10)	0.8	(11)	0.3	(12)	0.1
1985	(9)	0.4	(10)	**1.2**	(11)	0.3	(12)	0.2	(13)	0.1
1984	(10)	**1.2**	(11)	0.8	(12)	0.1	(13)	0.1		
1983	(11)	**0.8**	(12)	0.3						
1982	(12)	**0.4**	(13)	0.2						
N/aged		0.8		2.0		0.2		0.3		0.3
Total		**35.8**		**44.6**		**18.3**		**17.7**		**22.1**

Table 39. Catch rates (fish/day) of year classes of male striped bass sampled from variable-mesh gill nets in the James River, 30 March - 3 May, 1994-1998. Maximum annual catch rate (>0.1) for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	Catch Rate (fish/day)									
	1994		1995		1996		1997		1998	
1995									(3)	**1.2**
1994					(2)	0.1	(3)	1.6	(4)	**6.8**
1993			(2)	0.7	(3)	1.6	(4)	**3.9**	(5)	3.8
1992			(3)	**4.2**	(4)	2.8	(5)	2.3	(6)	1.7
1991	(3)	2.4	(4)	**7.9**	(5)	3.6	(6)	1.4	(7)	1.3
1990	(4)	**10.6**	(5)	6.3	(6)	1.5	(7)	1.3	(8)	0.2
1989	(5)	**8.0**	(6)	2.3	(7)	0.8	(8)	0.4	(9)	0.0
1988	(6)	**1.4**	(7)	0.6	(8)	0.3	(9)	0.1	(10)	0.1
1987			(8)	0.4	(9)	0.1				
1986			(9)	0.1						
N/aged		0.8		1.4		0.1		0.0		0.1
Total		**23.2**		**24.0**		**10.9**		**11.1**		**15.2**

Table 40. Catch rates (fish/day) of year classes of female striped bass sampled from variable-mesh gill nets in the James River, 30 March - 3 May, 1994-1998. Maximum annual catch rate (>0.1) for any year class during the sampling period is in bold type. The small number in parentheses is the age of each year class during that year.

Year Class	Catch Rate (fish/day)									
	1994		1995		1996		1997		1998	
1994									(4)	**0.3**
1993							(4)	0.6	(5)	**1.4**
1992			(3)	0.1	(4)	0.1	(5)	1.0	(6)	**1.3**
1991			(4)	**1.0**	(5)	0.9	(6)	0.6	(7)	0.7
1990	(4)	1.8	(5)	**4.8**	(6)	1.5	(7)	0.7	(8)	0.6
1989	(5)	4.0	(6)	**7.4**	(7)	1.9	(8)	0.4	(9)	1.1
1988	(6)	**2.2**	(7)	2.1	(8)	0.7	(9)	1.3	(10)	0.7
1987	(7)	0.8	(8)	**2.2**	(9)	0.9	(10)	1.1	(11)	0.7
1986	(8)	0.8	(9)	**1.8**	(10)	0.8	(11)	0.3	(12)	0.1
1985	(9)	0.4	(10)	**1.2**	(11)	0.3	(12)	0.2	(13)	0.1
1984	(10)	**1.2**	(11)	0.8	(12)	0.2	(13)	0.1		
1983	(11)	0.8	(12)	0.3						
1982	(12)	0.4	(13)	0.2						
N/aged		0.0		0.6		0.1		0.3		0.2
Total		**12.4**		**22.6**		**7.4**		**6.7**		**7.2**

Table 41. Estimated annual and geometric mean survival (S) rates for year classes of striped bass (both sexes combined) sampled from gill nets in the James River, 30 March - 3 May, 1994-1998.

Year Class	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1995					------
1994			------	------	------
1993		------	------	------	------
1992	------	0.88	0.88	0.90	0.89
1991	------	0.51	0.44	0.84	0.57
1990	0.90	0.28	0.65	0.39	0.50
1989	0.80	0.28	0.64	0.64	0.55
1988	0.74	0.74	0.74	0.54	0.68
1987	------	0.65	0.65	0.60	0.63
1986	------	0.42	0.42	0.33	0.39
1985	------	0.25	0.74	0.50	0.45
1984	0.65	0.38	0.38	0.00	0.33
1983	0.42	0.00			0.19
1982	0.56	0.00			0.25

Table 42. Estimated annual and geometric mean survival (S) rates for year classes of male striped bass sampled from gill nets in the James River, 30 March - 3 May, 1994-1998.

Year Class	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1995					------
1994			------	------	------
1993		------	------	0.97	0.97
1992		0.66	0.83	0.72	0.74
1991	------	0.46	0.40	0.92	0.55
1990	0.60	0.24	0.89	0.17	0.38
1989	0.29	0.34	0.56	0.00	0.28
1988	0.40	0.54	0.61	0.61	0.53
1987		0.23	0.00		0.11
1986		0.00			0.00

Table 43. Estimated annual and geometric mean survival (S) rates for year classes of female striped bass sampled from gill nets in the James River, 30 March - 3 May, 1994-1998.

Year Class	94-95 S	95-96 S	96-97 S	97-98 S	Mean S
1994					------
1993				------	------
1992		------	------	------	------
1991		0.90	0.86	0.86	0.87
1990	------	0.31	0.45	0.83	0.49
1989	------	0.26	0.77	0.77	0.53
1988	0.96	0.80	0.80	0.50	0.74
1987	------	0.71	0.71	0.60	0.67
1986	------	0.45	0.42	0.33	0.40
1985	------	0.25	0.74	0.50	0.45
1984	0.65	0.26	0.56	0.00	0.34
1983	0.42	0.00			0.19
1982	0.56	0.00			0.25

Table 44. Values of the spawning stock biomass index (SSBI) calculated from gill net catches of male and female striped bass in the James River, 30 March - 3 May, 1994-1998.

Year	n		SSBI (kg/day)		
	Male	Female	Male	Female	Combined
1998	134	65	32.97	46.48	79.45
1997	100	60	23.89	44.59	68.48
1996	108	74	23.70	43.35	67.05
1995	210	202	52.10	125.15	177.25
1994*	119	64	46.27	65.74	107.78
Mean	**134**	**93**	**34.50**	**64.48**	**98.98**

*Note: the 1994 data consisted of one gill net (GN # 1)
Totals were adjusted as follows:
Male 1.806 x GN # 1
Female 1.928 x GN # 2

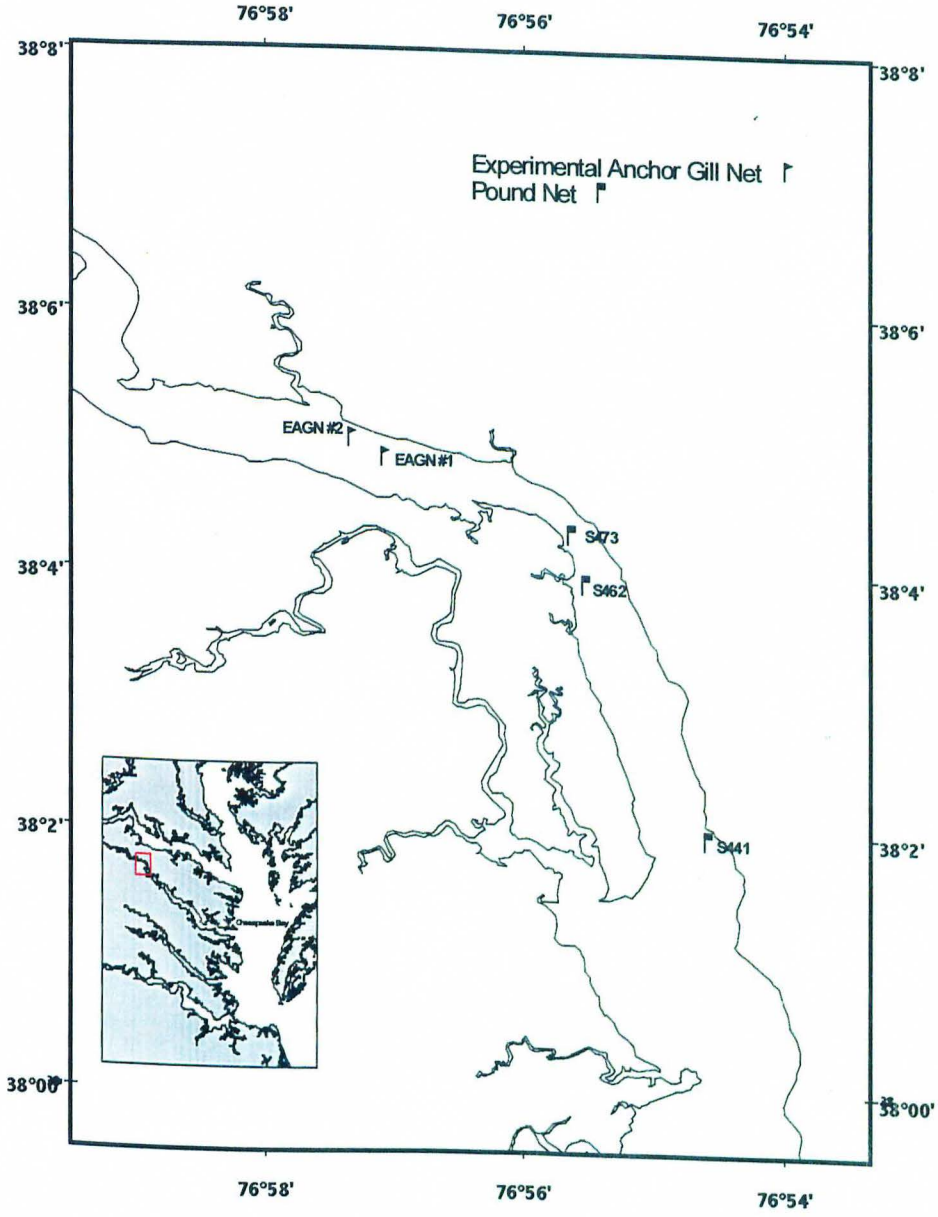


Figure 1. Locations of commercial pound nets and experimental gill nets sampled in spring spawning stock assessments of striped bass in the Rappahannock River, 1993-1998.

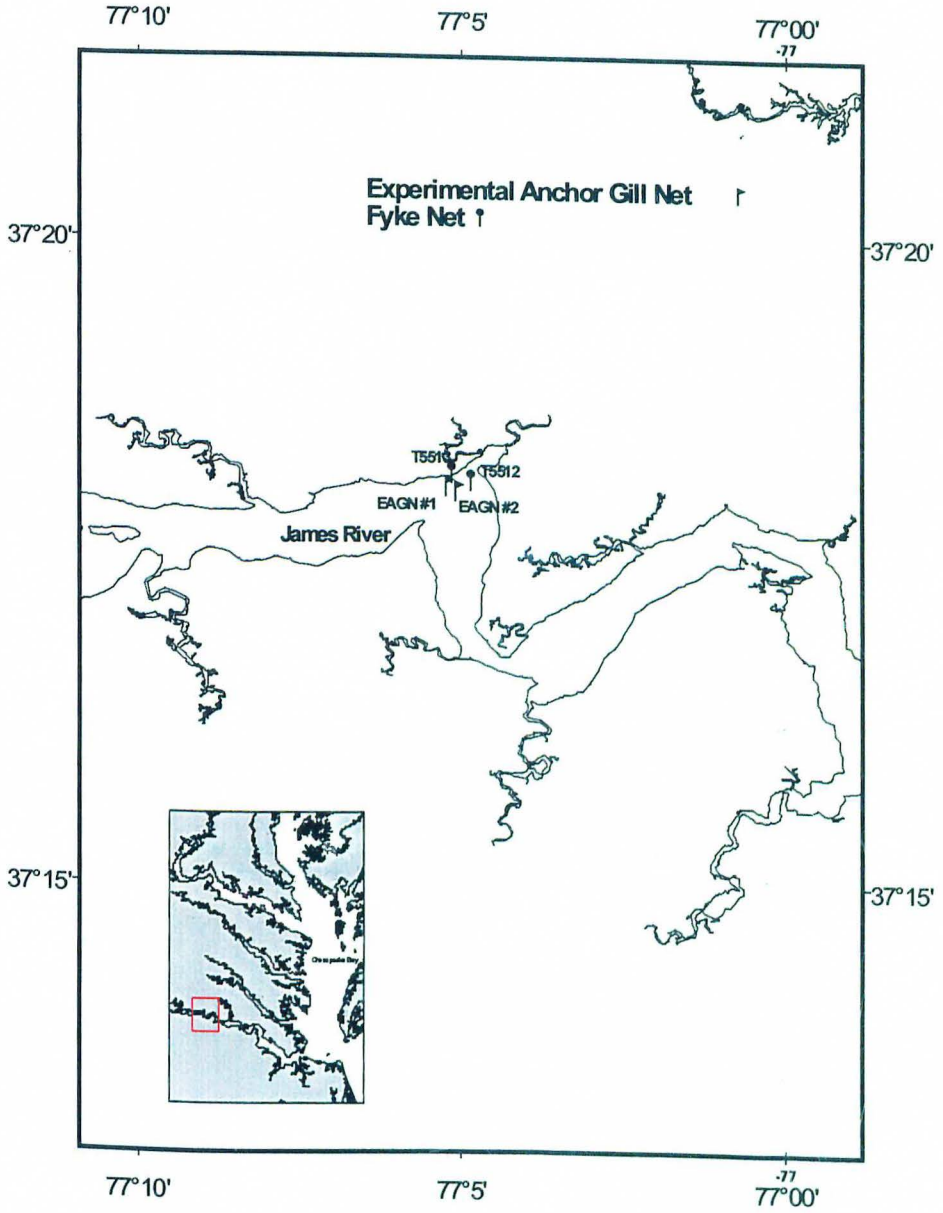


Figure 2. Locations of fyke nets and experimental gill nets sampled in spring spawning stock assessments of striped bass in the James River, 1994-1998.

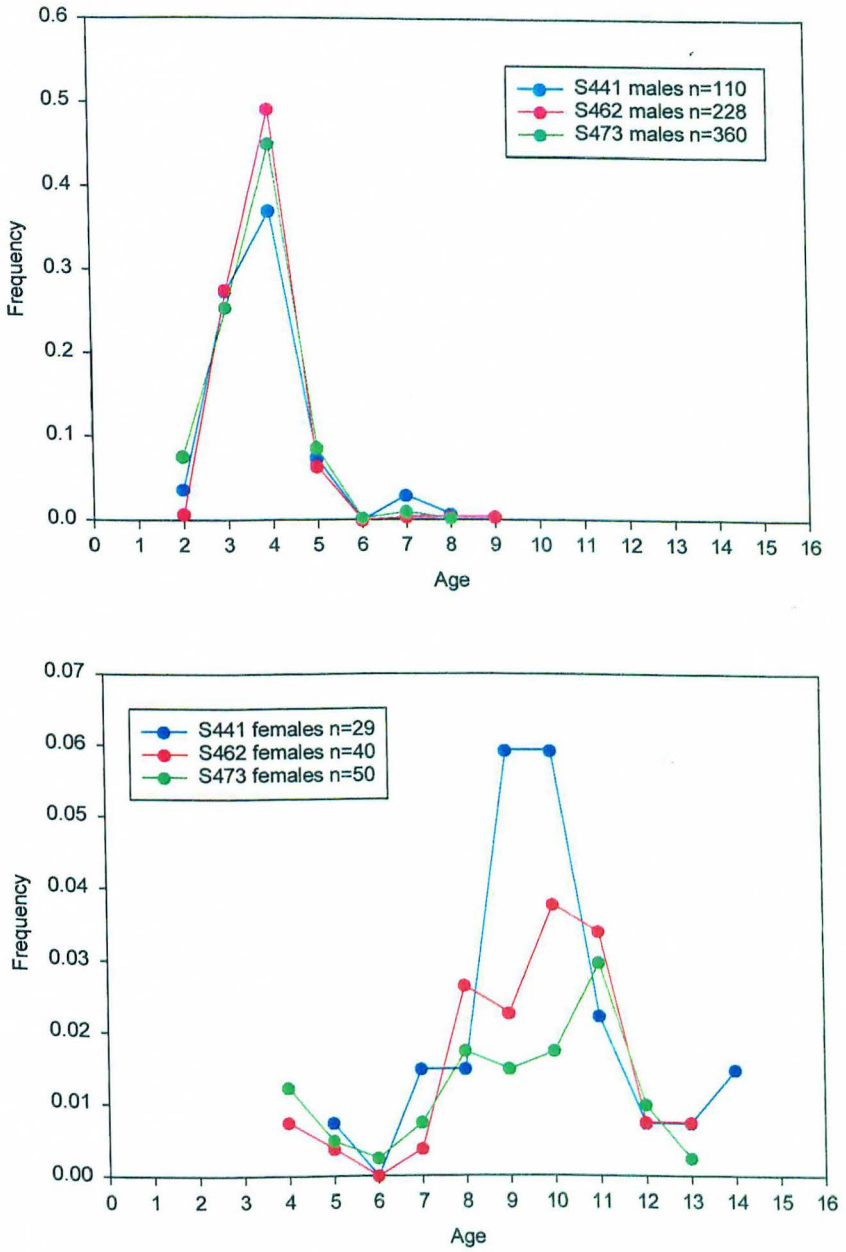


Figure 3. Age composition of male and female striped bass in three pound nets in the Rappahannock River, spring 1998.

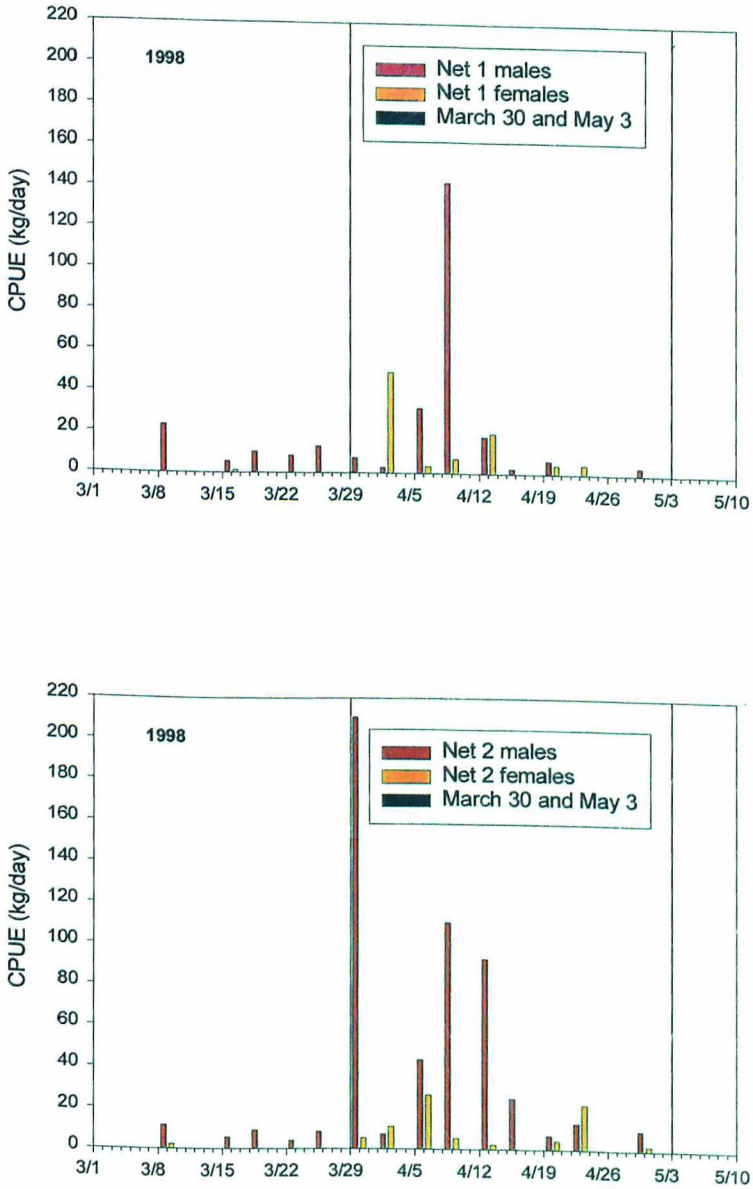


Figure 4. Catch rates (kg/day) of male and female striped bass in two variable mesh gill nets in the Rappahannock River, spring 1998. Vertical lines denote a restricted sampling window between 30 March and 3 May used in the analysis.

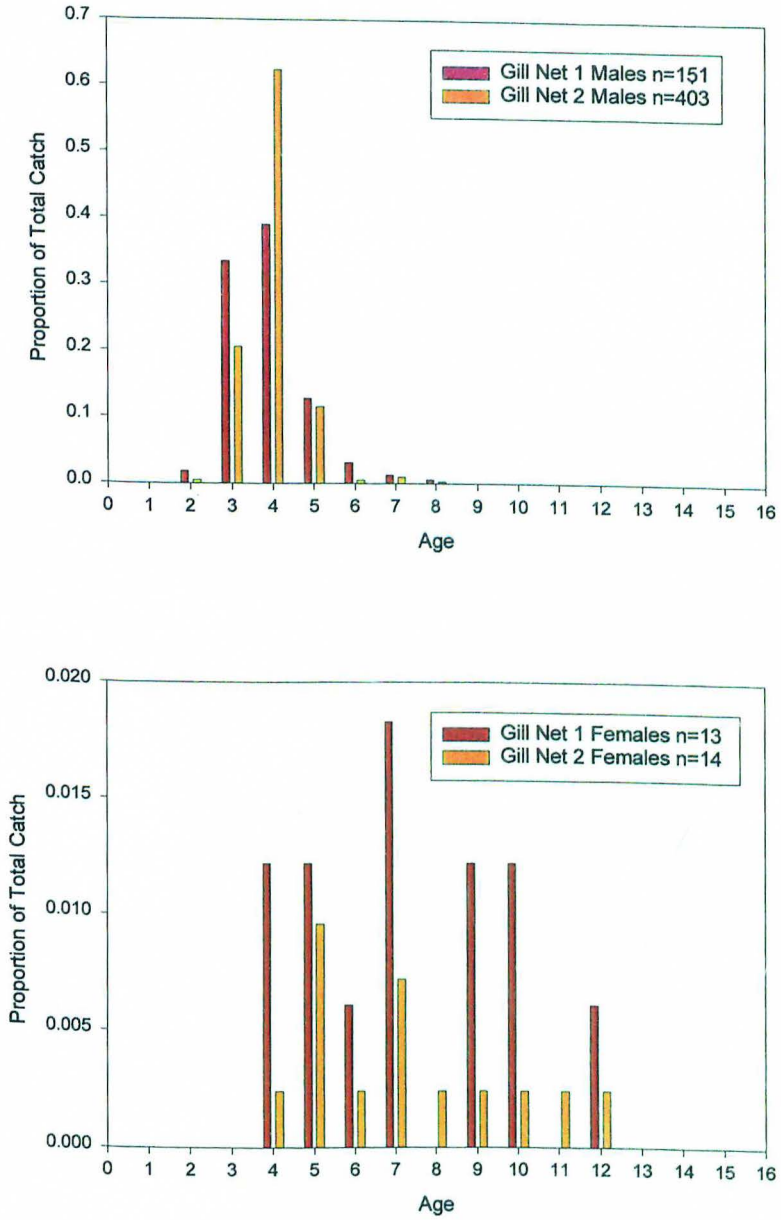


Figure 5. Age composition of male and female striped bass in two variable mesh gill nets in the Rappahannock River, spring 1998.

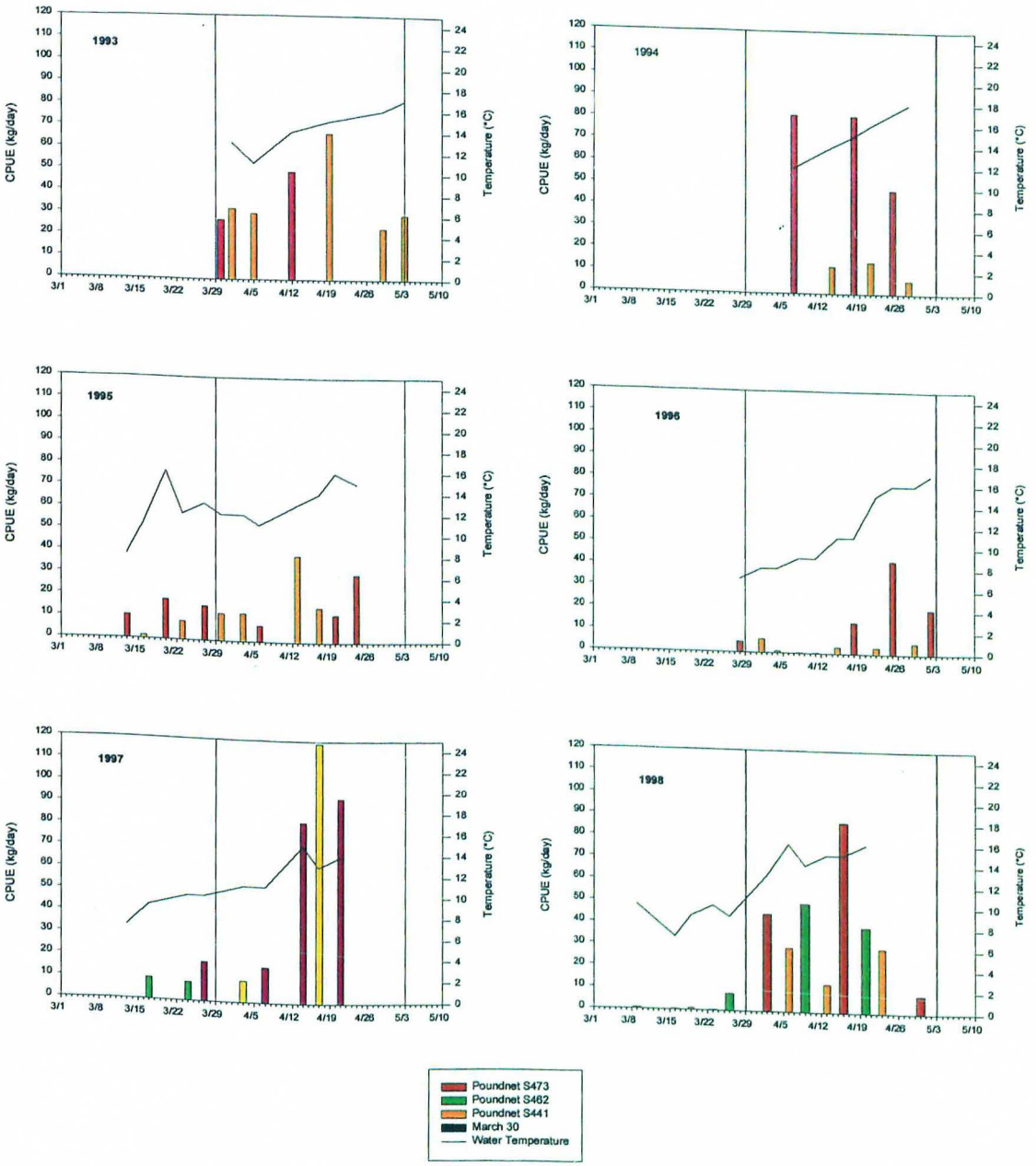


Figure 6. Seasonal surface water temperature (^{0}C) and catch rates (kg/day) of female striped bass in three pound nets in the Rappahannock River, spring 1993-1998. Vertical lines denote a restricted sampling window between 30 March and 3 May used in the analysis.

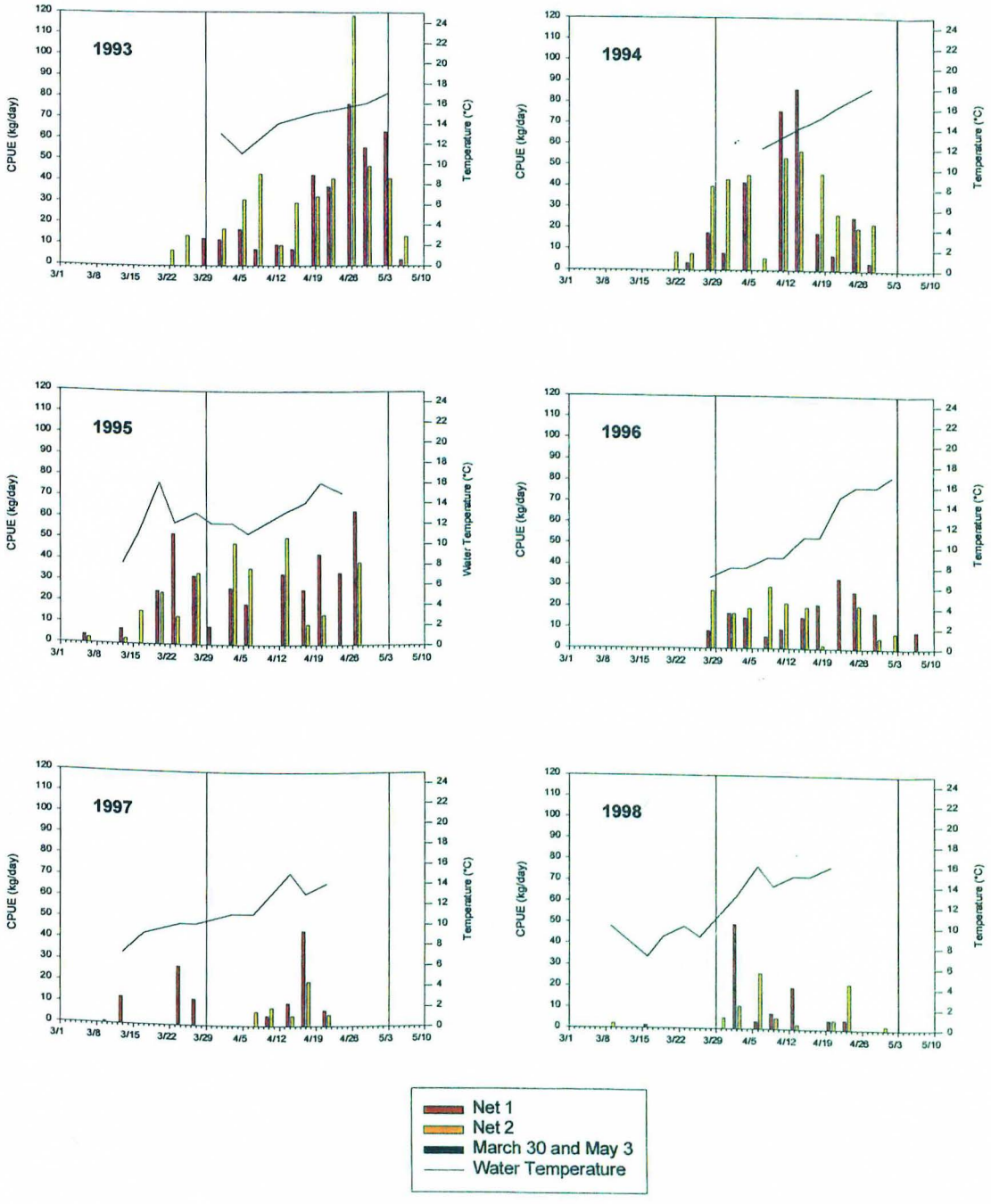


Figure 7. Seasonal surface water temperature (^{0}C) and catch rates (kg/day) of female striped bass in variable mesh gill nets in the Rappahannock River, spring 1993-1998. Vertical lines denote a restricted sampling window between 30 March and 3 May used in the analysis.

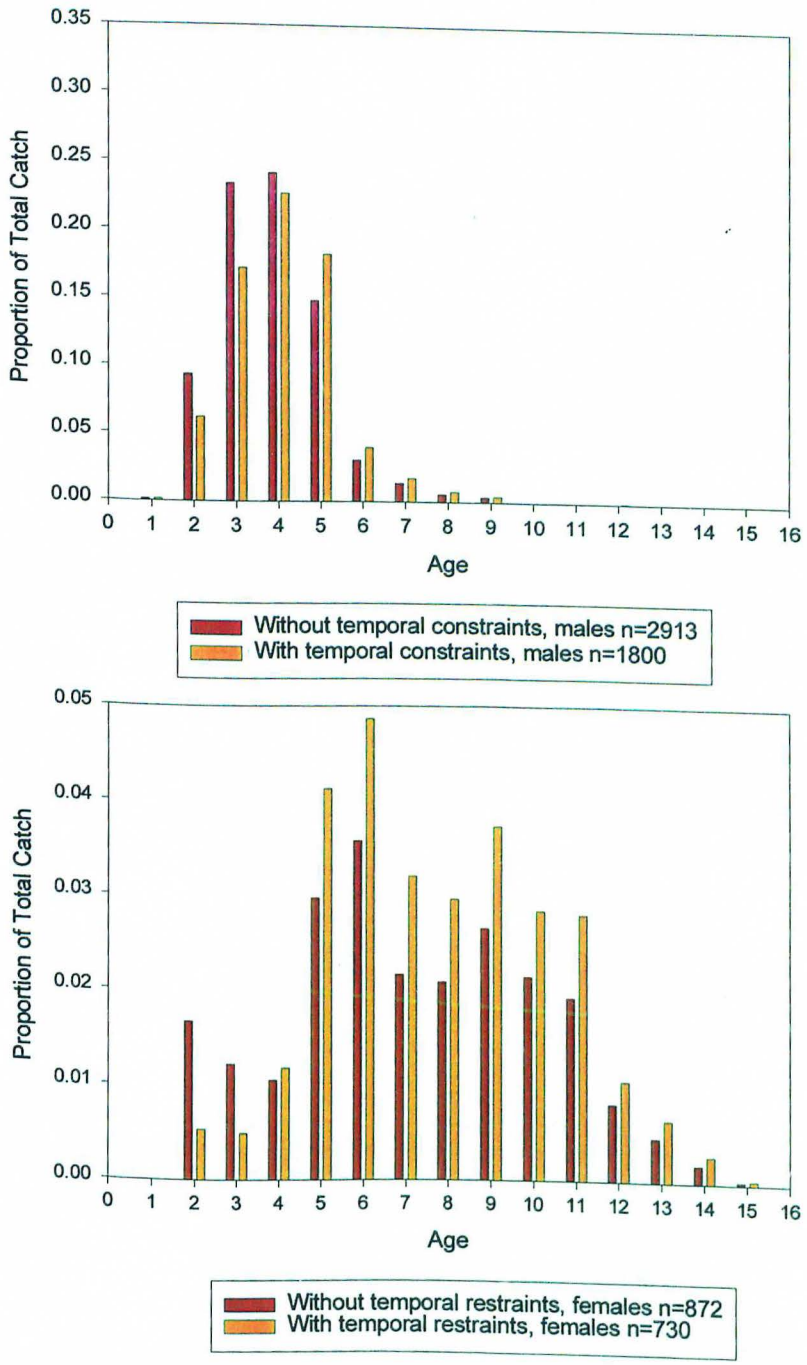


Figure 8. Cumulative age composition of male and female striped bass in pound nets in the Rappahannock River, spring 1993-1998. Upper panel: Comparison of ages of males captured during the entire season and restricted sampling season; Lower panel: Comparison of ages of females captured during the entire season and the restricted sampling window between 30 March and 3 May.

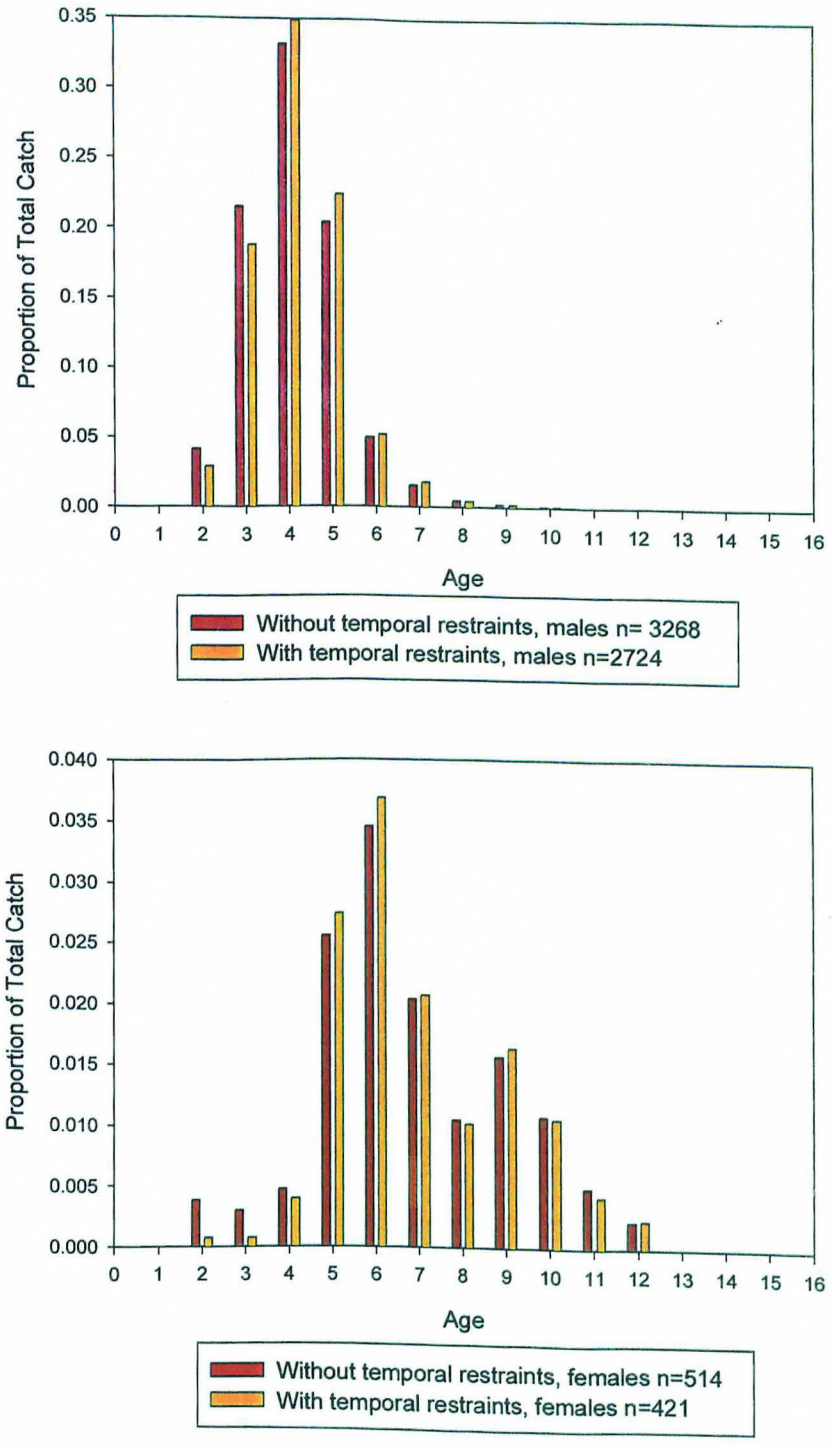


Figure 9. Cumulative age composition of male and female striped bass in variable mesh gill nets in the Rappahannock River, spring 1993-1998. Upper panel: Comparison of ages of males captured during the entire season and restricted sampling season; Lower panel: Comparison of ages of females captured during the entire season and a restricted sampling window between 30 March and 3 May.

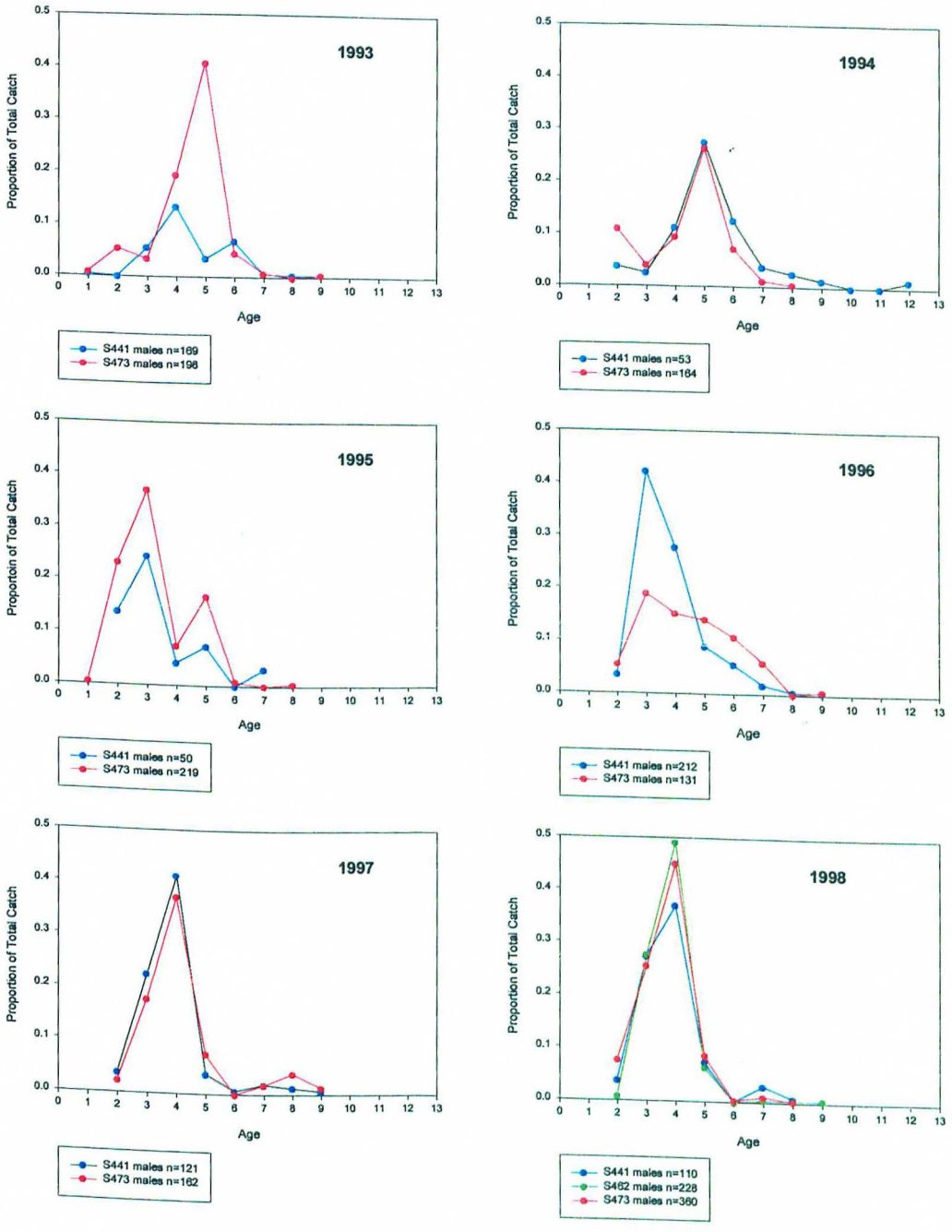


Figure 10. Age composition of male striped bass in pound nets in the Rappahannock River, 30 March-3 May, 1993-1998.

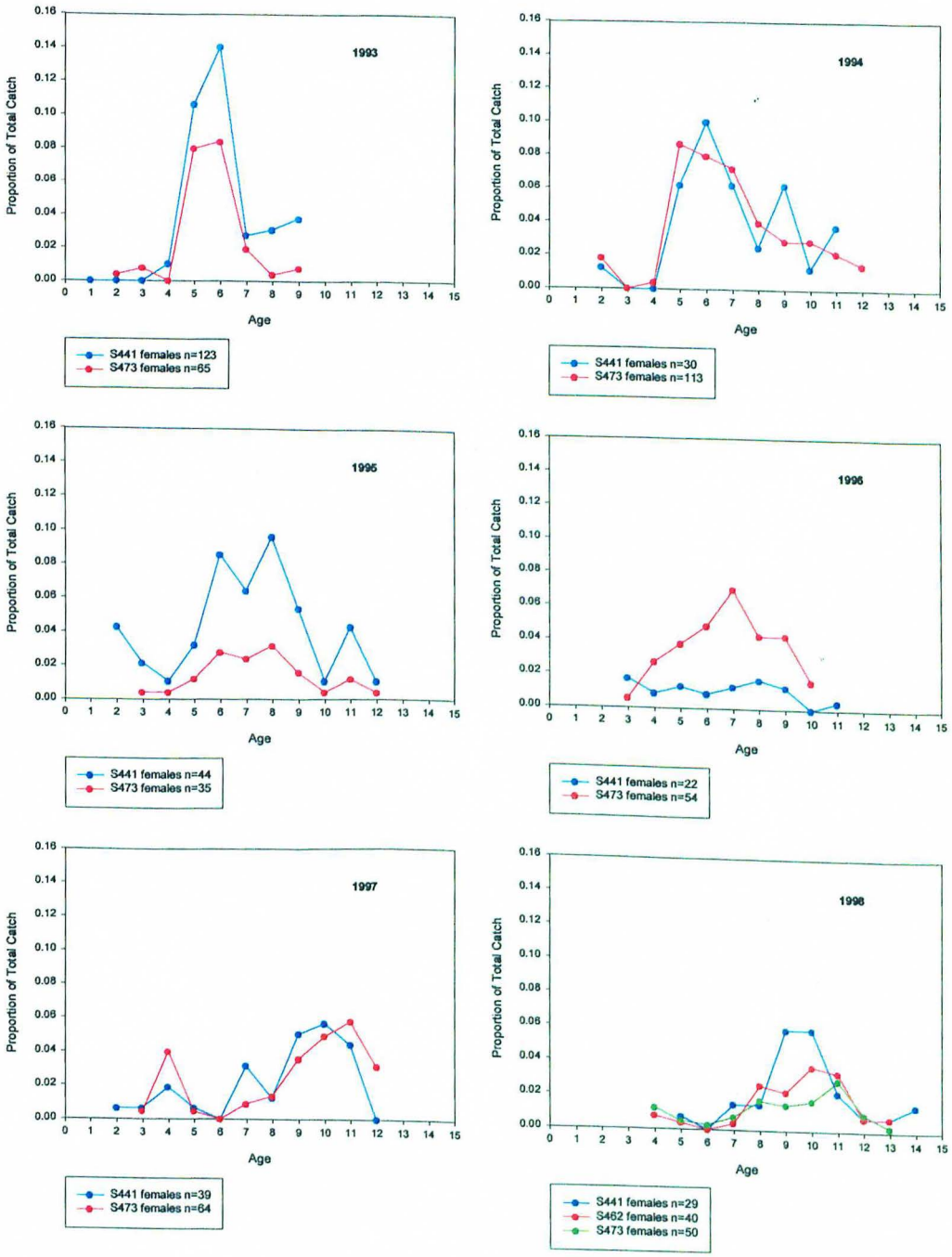


Figure 11. Age composition of female striped bass in pound nets in the Rappahannock River, 30 March-3 May, 1993-1998.

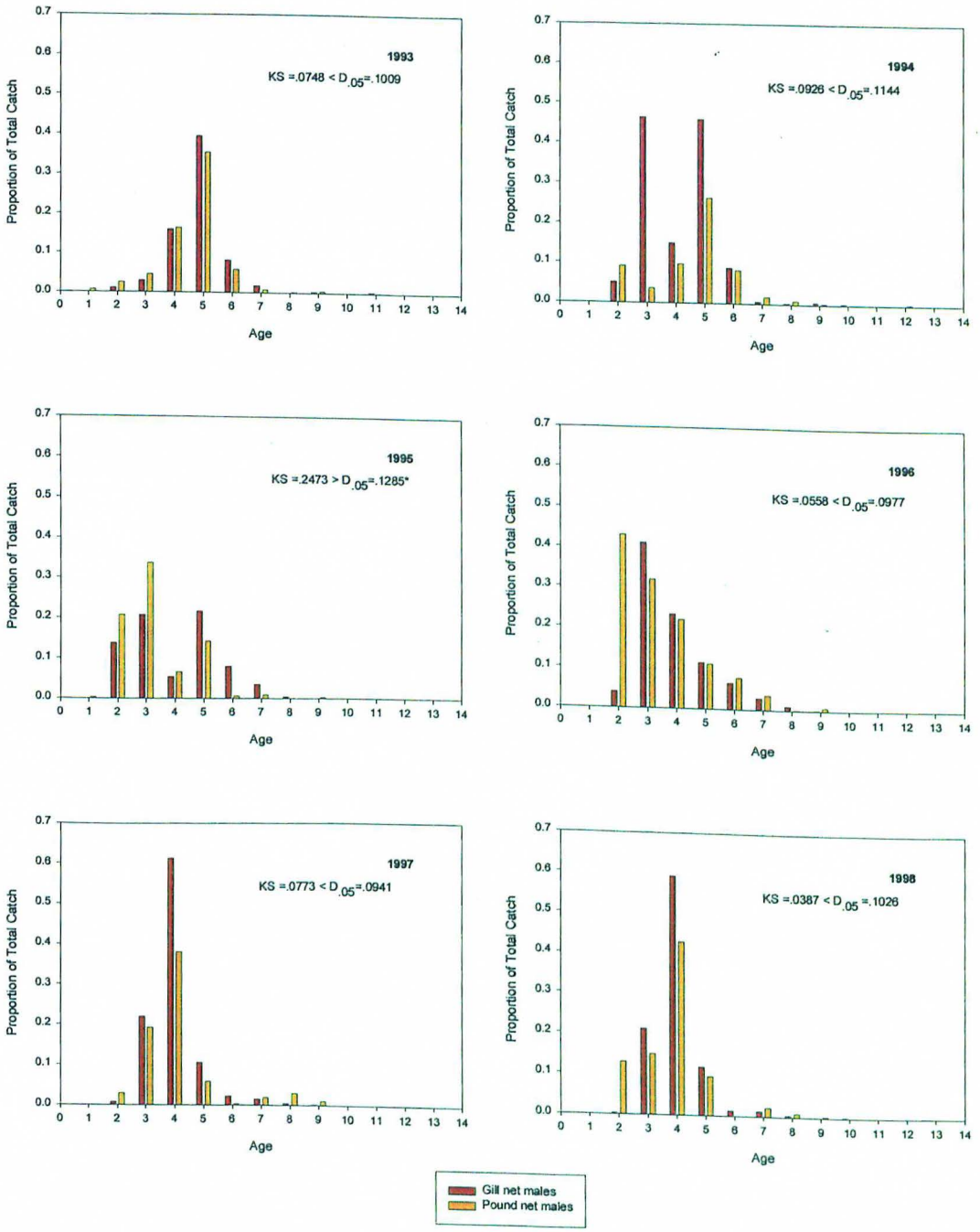


Figure 12. Comparison of the age composition of male striped bass in pound nets and gill nets in the Rappahannock River, 30 March-3 May, 1993-1998.

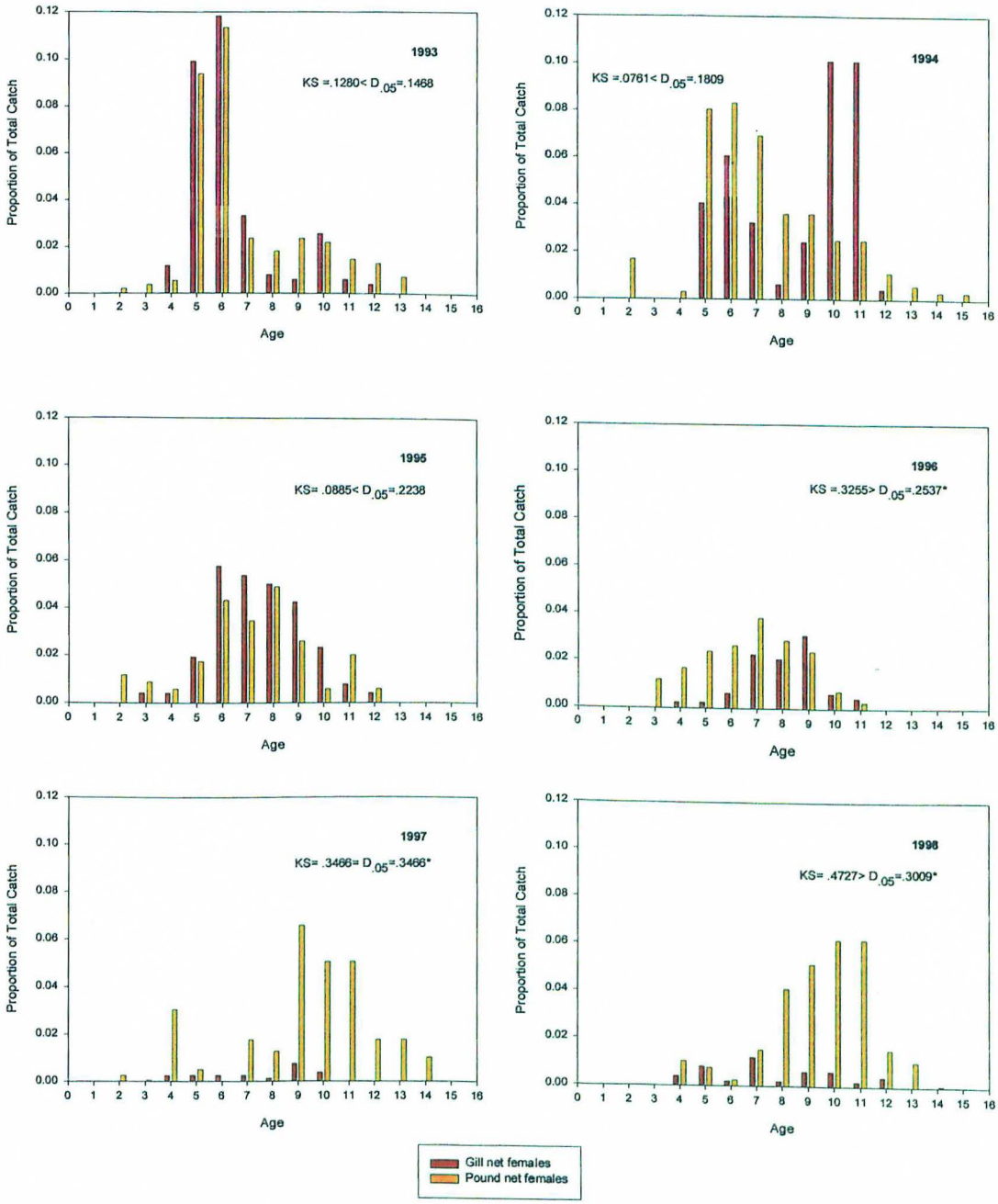


Figure 13. Comparison of the age composition of female striped bass in pound nets and gill nets in the Rappahannock River, 30 March-3 May, 1993-1998.

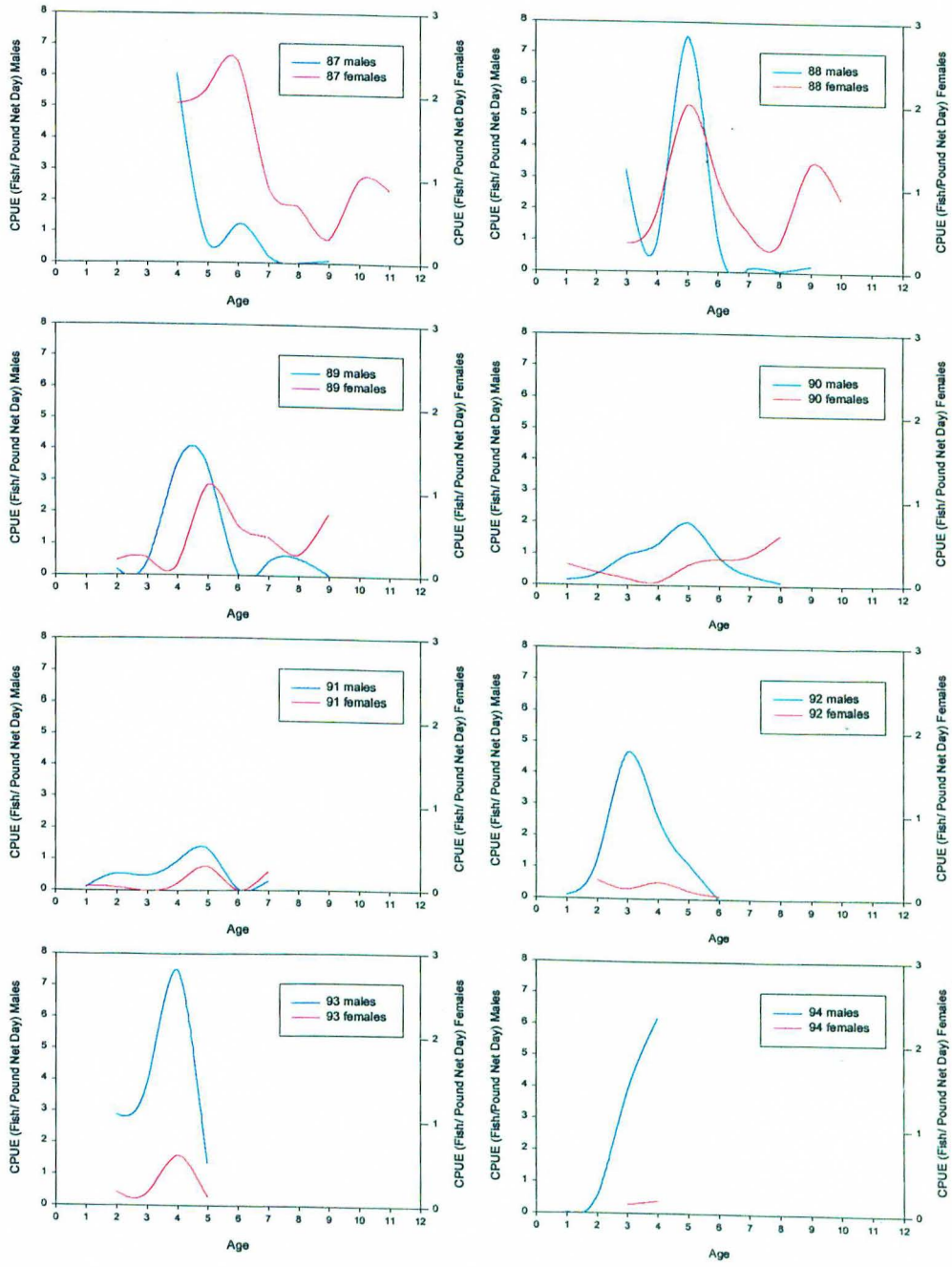


Figure 14. Catch-rates (numbers of fish per day) of eight year classes (1987-1994) of male and female striped bass in pound nets in the Rappahannock River, 30 March-3 May, 1993-1998.

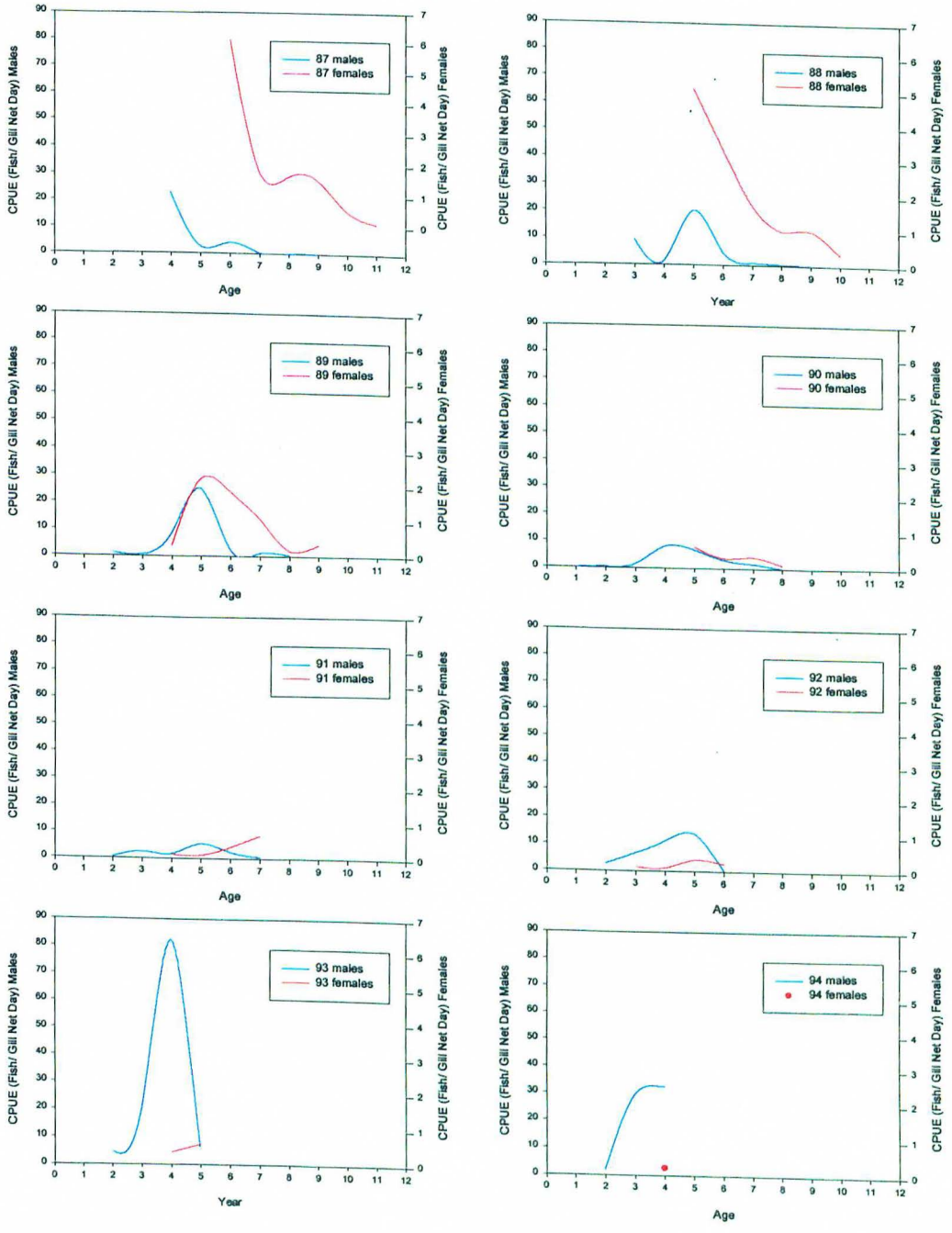
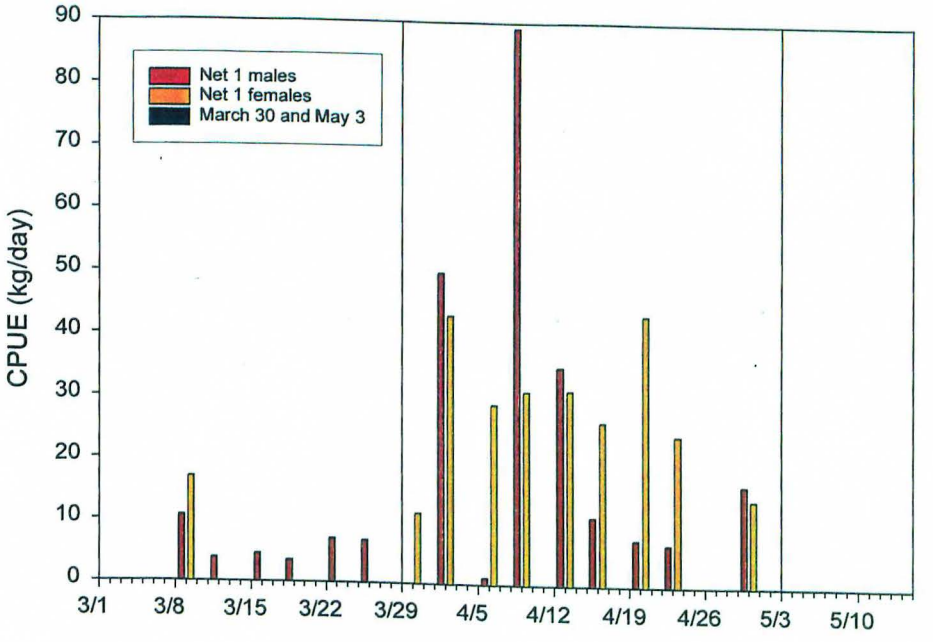


Figure 15. Catch rates (numbers of fish per day) of eight year classes (1987-1994) of male and female striped bass in variable mesh gill nets in the Rappahannock River, 30 March-3 May, 1993-1998.



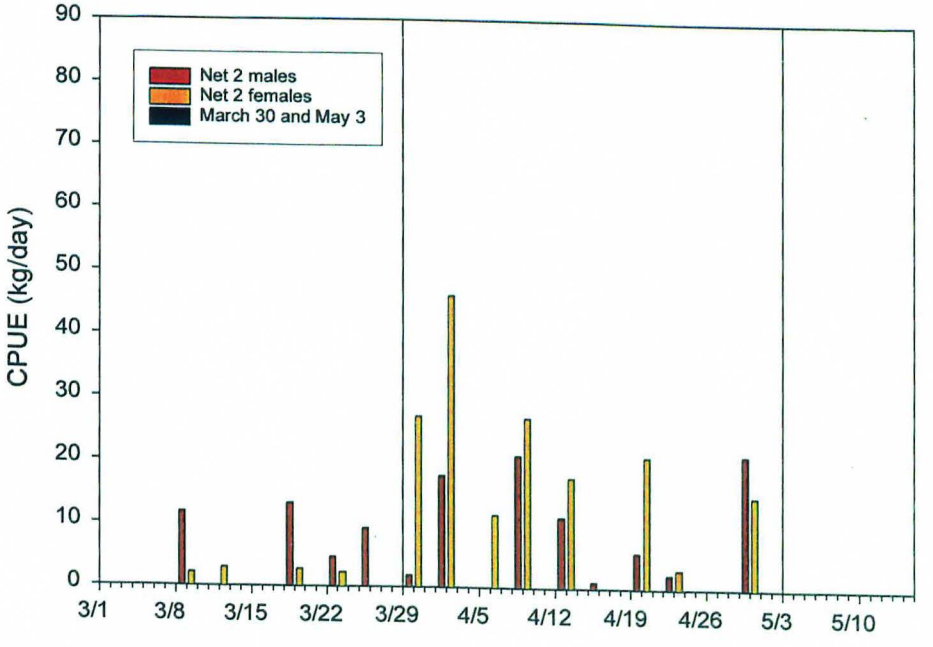


Figure 16. Catch rates (kg/day) of male and female striped bass in two variable mesh gill nets in the James River, spring 1998. Vertical lines denote a restricted sampling window between 30 March and 3 May used in the analysis.

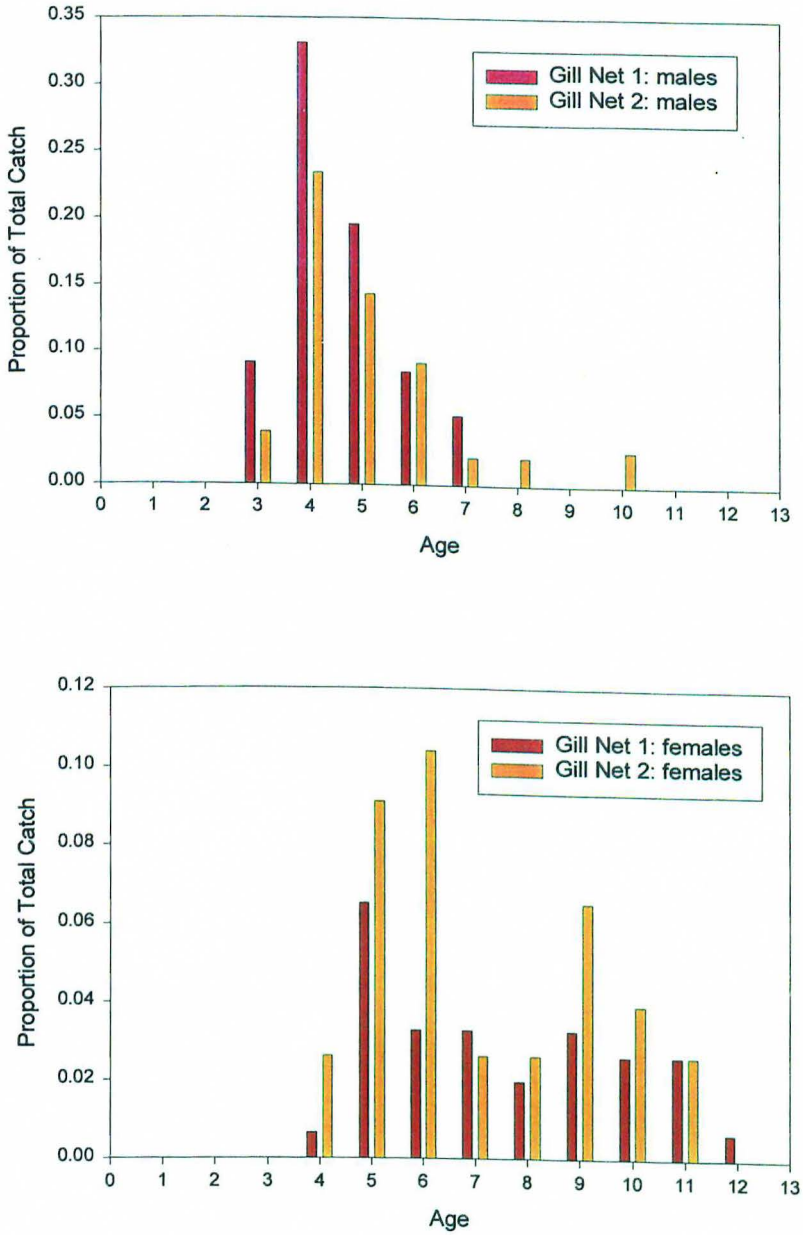


Figure 17. Age composition (as a proportion of the total catch) of male and female striped bass in two variable mesh gill nets in the James River, spring 1998.

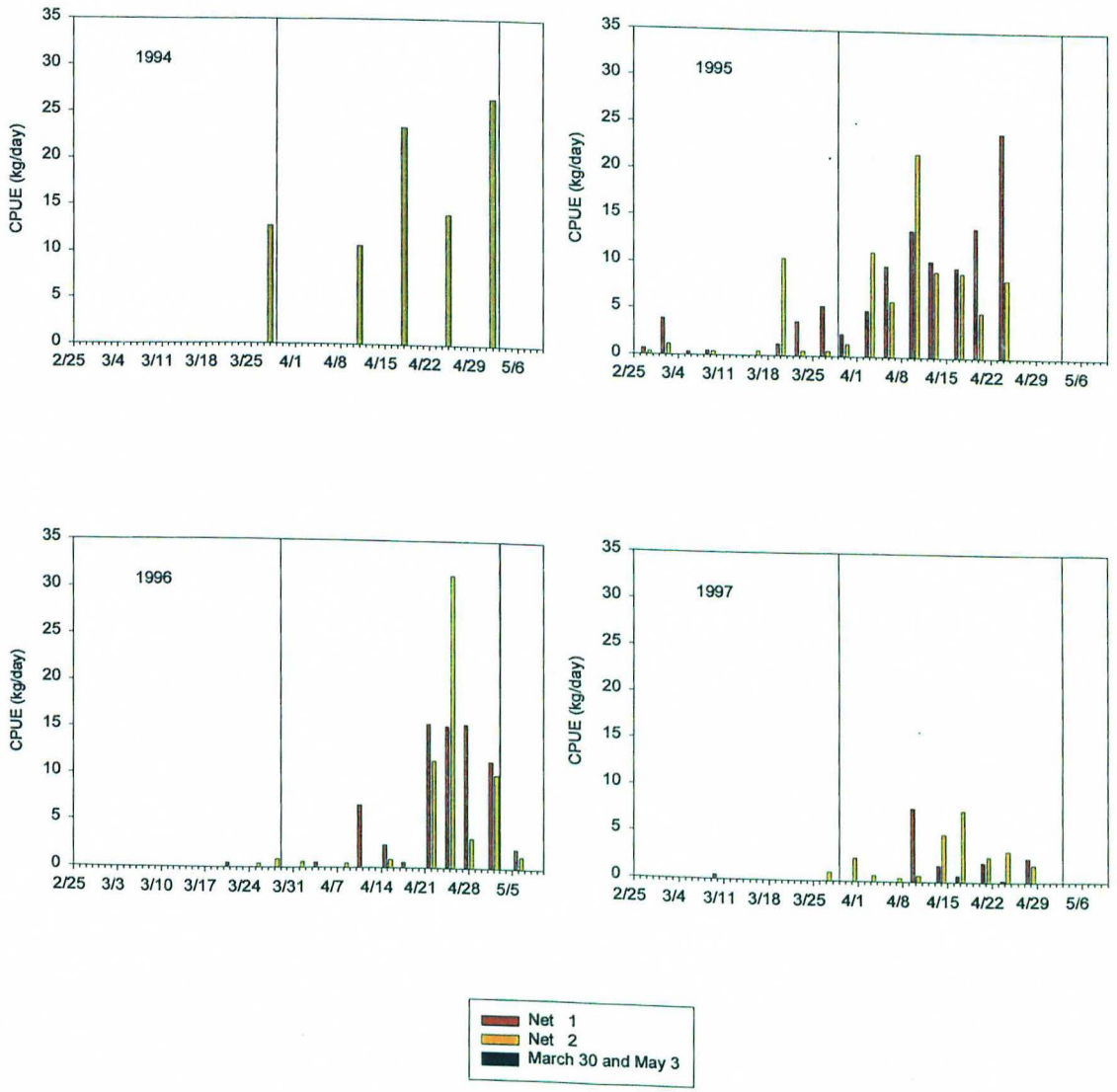


Figure 18. Catch rates (kg/day) of female striped bass in fyke nets in the James River, spring 1994-1997. Vertical lines denote a restricted sampling window between 30 March and 3 May used in the analysis.

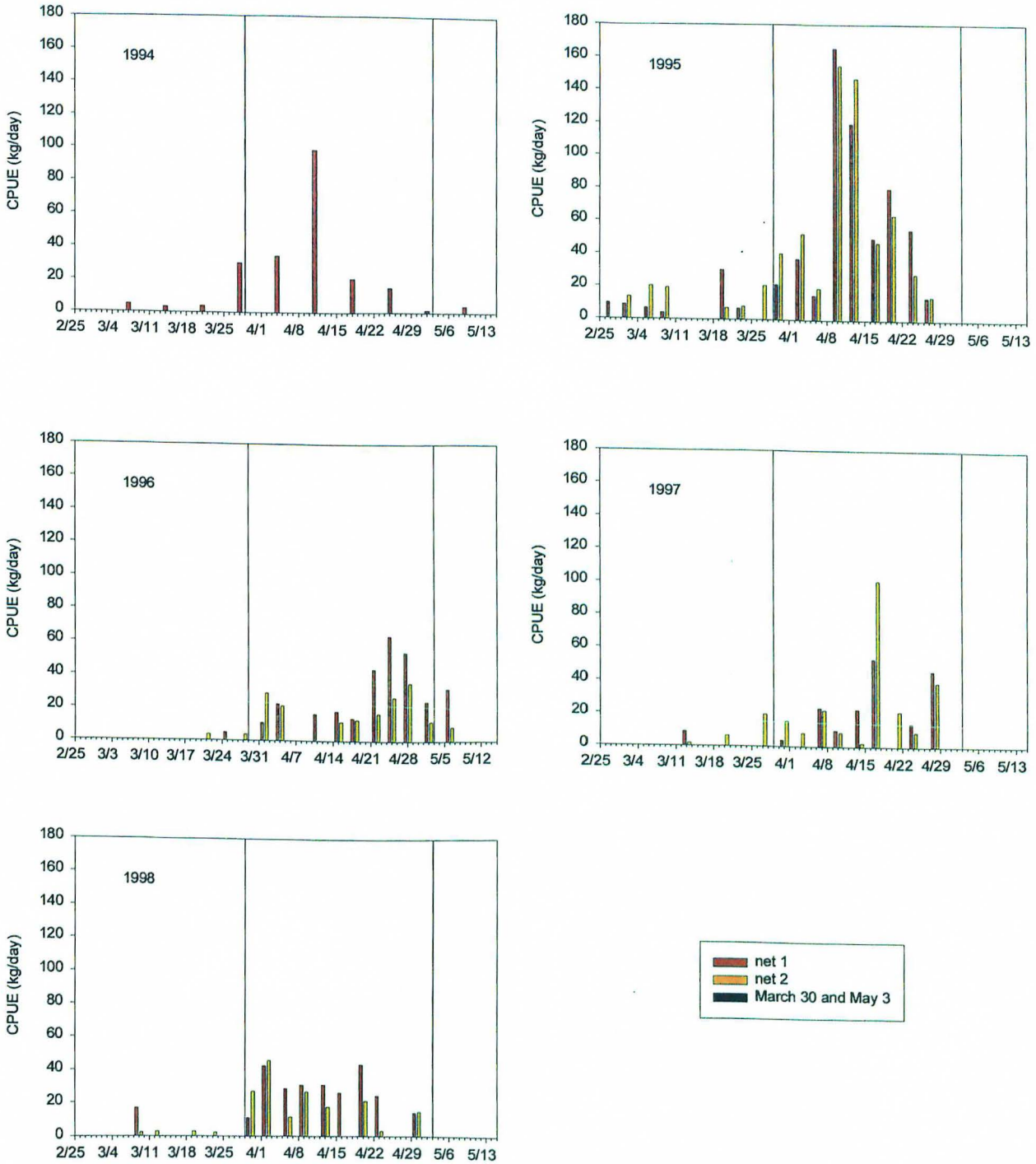


Figure 19. Catch rates (kg/day) of female striped bass in variable mesh gill nets in the James River, spring 1994-1998. Vertical lines denote a restricted sampling window between 30 March and 3 May used in the analysis.

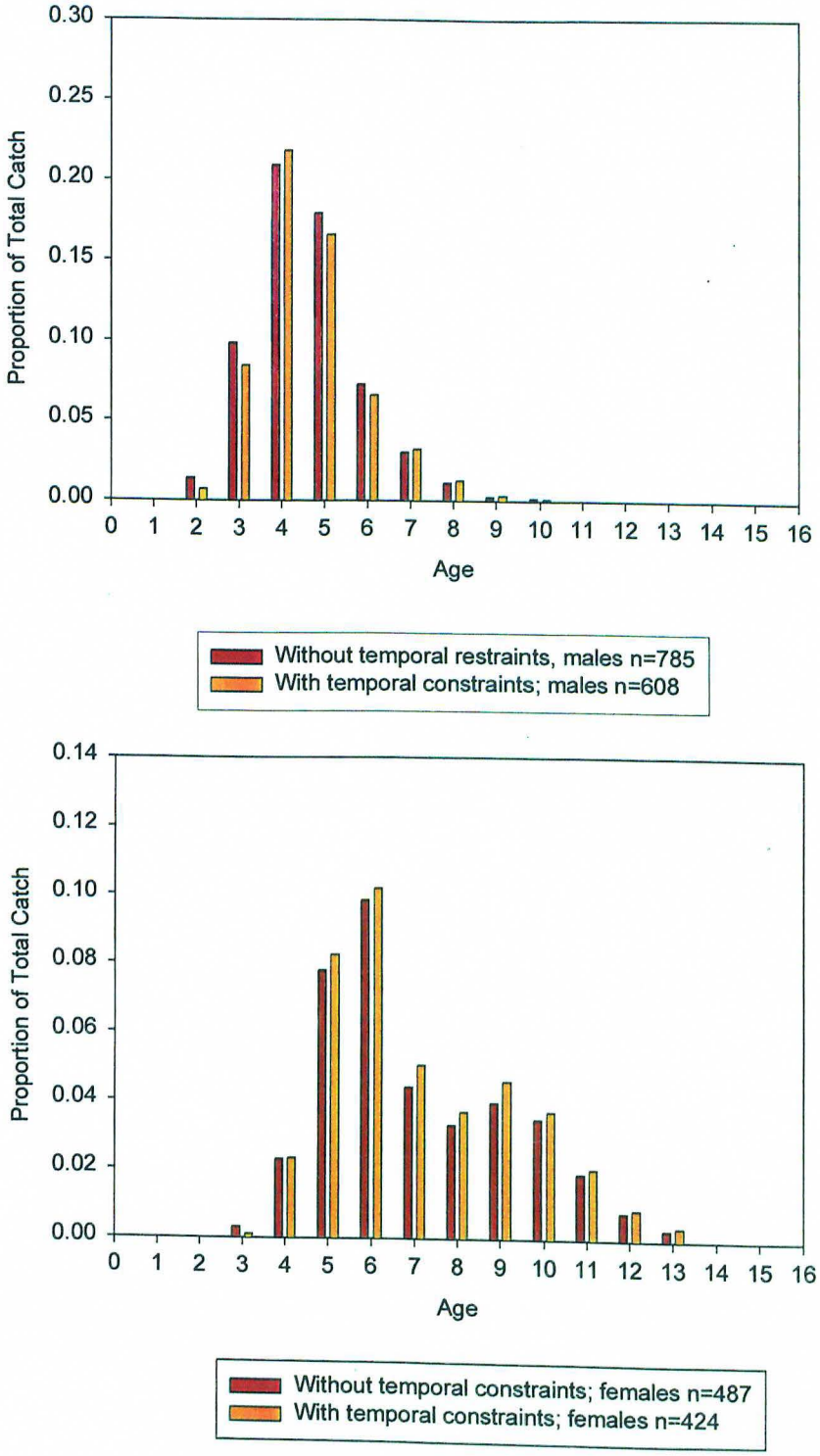


Figure 20. Cumulative age composition of male and female striped bass in the James River (spring 1998). Upper panel: Comparison of ages of males captured during the entire season and restricted sampling season; Lower panel: Comparison of ages of females captured during the entire season and a restricted sampling window between 30 March and 3 May.

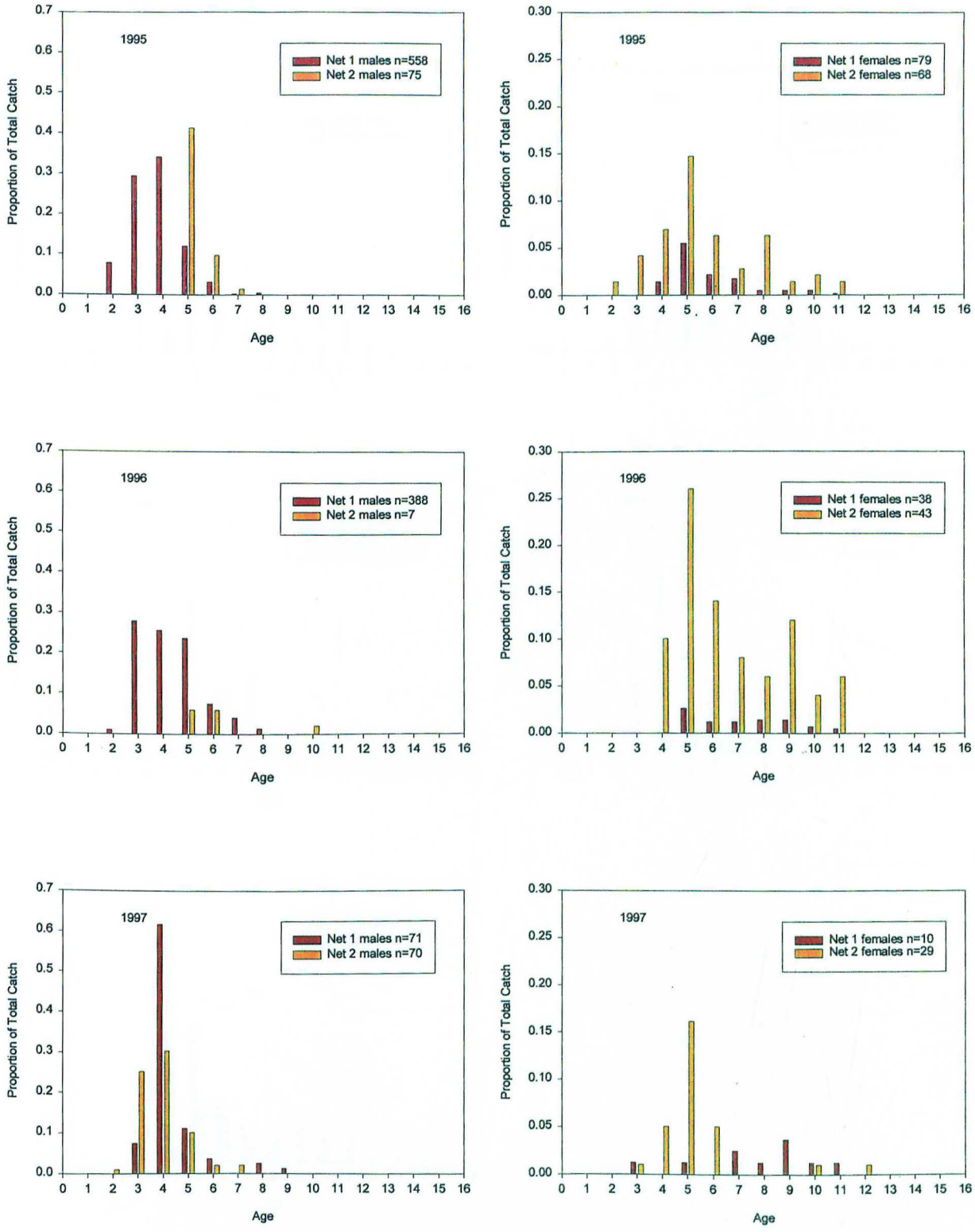


Figure 21. Age composition (as a proportion of the total catch) of male and female striped bass in two fyke nets in the James River, spring 1995-1997.

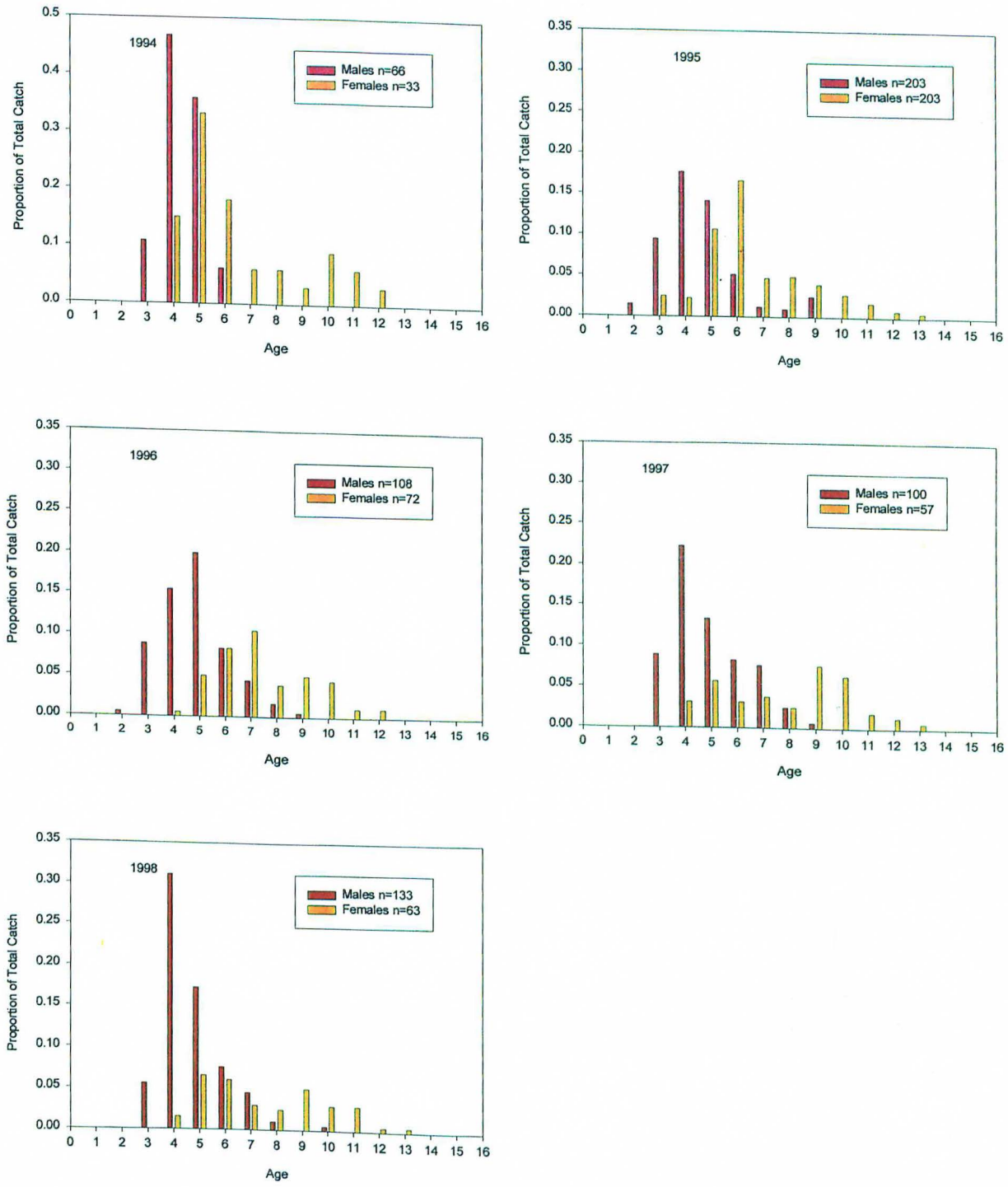


Figure 22. Age composition of male and female striped bass in variable mesh gill nets in the James River, 30 March-3 May, 1994-1998.

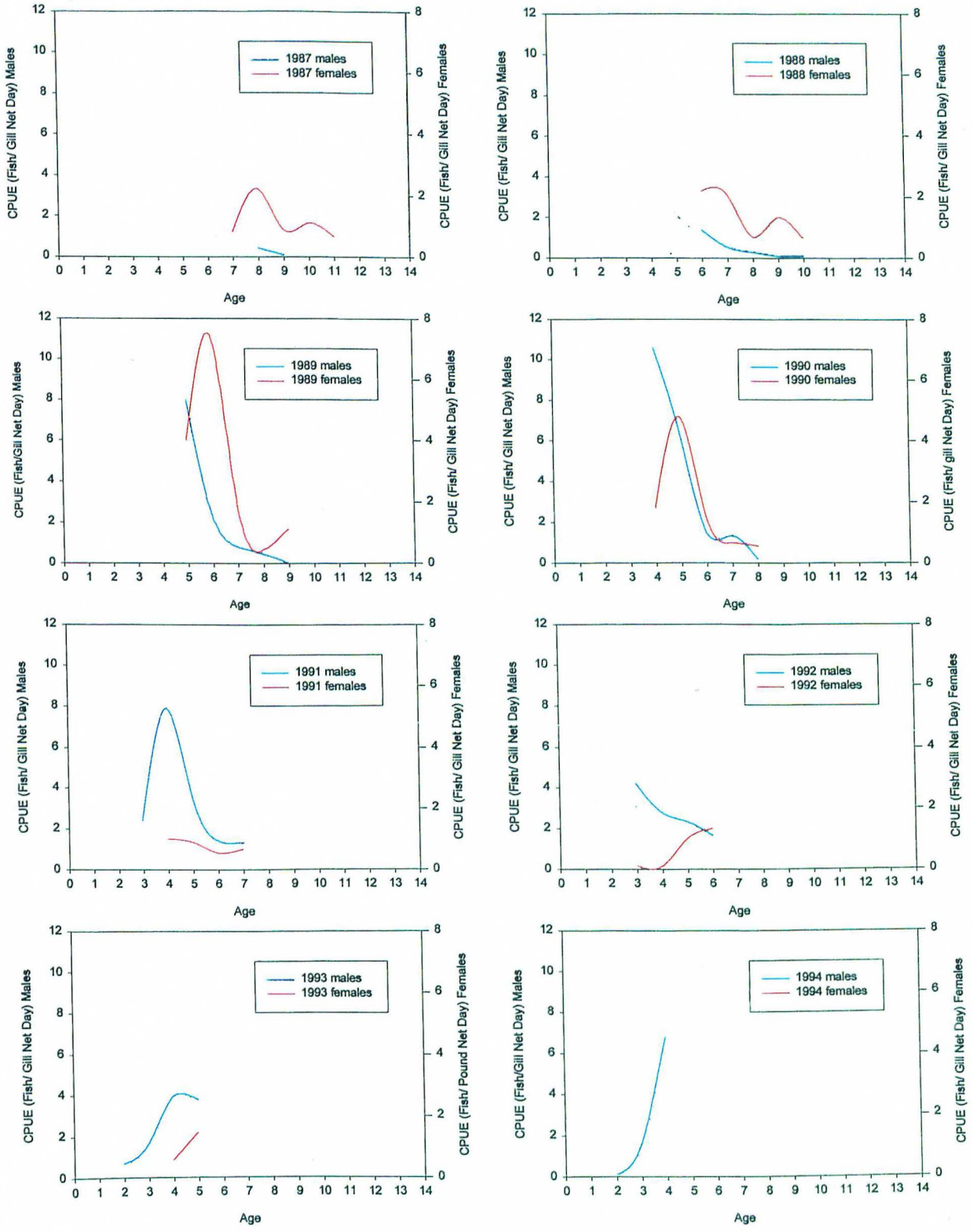


Figure 23. Catch rates (numbers of fish per day) of eight year classes (1987-1994) of male and female striped bass in variable mesh gill nets in the James River, 30 March-3 May, 1993-1998.